KADİR HAS UNIVERSITY
SCHOOL OF GRADUATE STUDIES
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SPATIAL IMPACTS OF URBAN INFRASTRUCTURE: ISTANBUL MARMARAY CASE

HASAN CAN ORHAN

MASTER THESIS

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MASTER THESIS

Submitted to the Graduate School of Kadir Has University in partial fulfillments or the requirements for the degree of Master of Science in Architectural and Urban Studies Master Program

ISTANBUL, JULY, 2020

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This work entitled **SPATIAL IMPACTS OF URBAN INFRASTURCTURE: ISTANBUL MARMARAY** prepared by **HASAN CAN ORHAN** has been judged to be successful at the defense exam on **22 July 2020** and accepted by our jury as MASTER THESIS.

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ABSTRACT

Property markets are strictly affected by the infrastructure networks. This study explores the impacts of urban infrastructure projects on urban space and housing. From this point forth, the research questions are built upon a case study: Marmaray Mass Rapid Railway System that ties the separated suburban train systems locating on European and Asian sides in Istanbul through an underwater tunnel. These impacts are aimed to observe by analysing the standard land values. Street-based standard land values are specified as the datasets in which population data are also inserted. In this process, conceptualising the network-city relationship is the first step whereas the initial rent theories are studied in the following. After the impacts of urban transportation projects on the property market are reviewed in contemporary literature, it presents a brief history of Istanbul macro form in relation to urban transportation.

For the analysis 2010, 2014 and 2018 are chosen as the dataset since 2010 is when the suburban train systems are still in operation; 2013 is when the suburban train systems stop working due to the construction of a new system which is namely the Marmaray. 2014 and 2018 are the date when the Marmaray is partly operated. Specified datasets are analysed in the way of agglomerative hierarchical analysis. Afterwards, clustered groups are visualised on the geographical information systems. Findings indicate that major changes are not displayed on the general view maps and neighbourhood-based maps. However, significant findings are monitored on the street-based maps where findings are observed in detail. By this way, changes of values around the train stations are observed. To sum up, the absence of the suburban train systems causes a change of distribution balance of values more than their existence. Besides, the impacts of the absence of the system are not majorly viewed in the saturated areas. Also, for the areas around the Marmaray train stations that are partly operated, it is indicated some agglomerative increases.

Keywords: Marmaray, Infrastructure, Urban Transportation, Housing, Istanbul.

KENTSEL ALTYAPININ MEKÂNSAL ETKİLERİ:
İSTANBUL MARMARAY ÖRNEĞİ

ÖZET

Konut piyasası, altyapı projeleri tarafından oldukça etkilenir. Bu çalışma kentsel altyapı projelerinin kentsel mekân ve konut üzerindeki etkilerini incelemektedir. Bu noktadan hareketle, araştırma soruları bir durum çalışması üzerine kurulmuştur. Durum çalışması İstanbul'un Asya ve Avrupa yakalarında bulunan banliyö trenlerini iyileştirilmesi ve deniz altı tünel ile birleştirilmesini amaçlayan Marmaray tren sistemi üzerine kurulmuştur. Konut değerlerinin analizi ile birlikte mekânsal profil değişimlerinin okunması sonucu etkilerin gözlemlenmesi amaçlanmaktadır. Temel veri kaynağı olarak nüfus verilerinin de eklendiği sokak bazında rayiç bedeller alınmıştır. Bu süreç içinde, ağların(network) ve şehrin ilişkisi kavramsallaştırıldıktan sonra kira (rent) teorisi irdelenmiştir. Güncel literatür içinde verilen kentsel ulaştırma projelerinin konut piyasasına etkileri irdelenmiş ve ardından İstanbul tarihsel makro formunun kentsel ulaştırmayla ilişkisi sunulmuştur.

Analiz için 2010, 2014 ve 2018 yılları seçilmiştir. Banliyö trenleri 2010 yılında çalışır vaziyette olup 2013 yılında Marmaray çalışmaları yüzünden durdurulmuştur. 2014 ve 2018 yılları, Marmaray sisteminin kısmi şekilde çalıştığı yıllardır. Belirlenen veri setleri kümelenmiş hiyerarşik analize sokulmuştur. Ardından kümelenmiş gruplar coğrafi bilgi sistemleri üzerinden görselleştirilmiştir. Bulgular, büyük değişimlerin mahalle bazında haritalar üzerinde görülemeyeceği, ancak sokak bazında incelenen detaylı haritalarda büyük değişimlerin gözlenebileceğini göstermiştir. Bu yolla, tren istasyonlarının çevresinde bulunan alanlardaki değer değişimleri gözlemlenmiştir. Özet olarak, banliyö tren sistemlerinin yokluğu günlük ulaşımda zorluk yarattığı için değerlerin denge dağılımlarını değiştirmiştir. Öte yandan, banliyö sisteminin yokluğu, kentsel merkezde doygun alanlarda büyük bir değer değişimine yol açmadığı gözlemlenmiştir. Ayrıca, kısmi şekilde çalışmaya açılan Marmaray tren istasyonlarının etrafında yığınsal bir değer artışı olduğu gözlemlenmiştir.

Anahtar Sözcükler: Marmaray, Altyapı, Kentsel Ulaşım, Konut, İstanbul.

ACKNOWLEDGEMENTS

Life is full of challenges. However, challenges in 2020 are the most effective ones for every single individual in the world. Throughout the time when we have faced with the challenges in 2020, our habits in everyday life have started to change. Cities, in this context, are the stage where the challenges take place. Therefore, we cannot perceive the cities within the same perspective anymore. This viewpoint has taught me so much when I wrote my thesis during the lockdown due to the pandemic affecting the globe.

I would like to thank Prof.Dr.Murat Güvenç who changes my approach to understanding spatial knowledge. Further, I would like to be grateful dear Assoc.Prof.Dr.G.Pelin Sarıoğlu Erdoğdu who has been always supporting me by her positive energy, friendly approach and knowledge since my bachelor degree in architecture. I would not have imagined being an urbanist if I have not met her. Thirdly, I feel a deep sense of gratitude to dear Gizem Fidan who has been always helpful with her deep patience to teach me the process.

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To my beloved niece,

Irmak

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ABBREVIATIONS

AHC Agglomerative Hierarchical Clustering

BRT Bus Transit System

CBD Central Business District

GIS Geographical Information Systems

LRT Light Rail Transit

VUK Vergi Usûl Kanunu (Tax Procedural Law)

TCDD Türkiye Cumhuriyeti Devlet Demiryolları (Turkish State Railways)

TDK Türk Dil Kurumu (Turkish Language Association)

1.INTRODUCTION

Property market, particularly housing, is under direct influence of the urban infrastructure projects. The changes of increase and decrease of housing value considerably depends on the impacts of the projects. Further, spatiotemporal effects of the projects may be perceived before the completion of them. Therefore, a word of mouth is sufficient for a spark to transform the urban space and its housing market. Eventually, values of urban lands and dwellings are pushed up in the context of land improvements. Main reasons what cause this alteration in urban area are the suitable access and proximity to the transportation facilities, especially railway projects, by the residents of the area. This comes into prominence when the traffic problem is one of the significant issues in the city.

Dynamic structure of Istanbul leads to major changes in spatial context. Spatial dynamics of the urban area highly depends on the mega-projects or another say large-scale projects. The urban transportation projects within the context of Istanbul are the ones of these large-scale project. Completed and ongoing projects transform the urban space of Istanbul which shape the city including its residents and their everyday life. Throughout the urbanisation process in Istanbul, means of transport and transportation projects have been the major factors those either add or lose in value of urban space. For the very reason of the supply-demand balance of the housing and construction market are concerned with those projects. Thus, the urban transportation is a dominant parameter in urban space. Specific to Istanbul, the housing market of the city which reaches the limit of its spectacular size, the urban transportation is a key factor quite a lot in order to determine the housing value. Due to many challenges in daily mobilisation in Istanbul, large-scale network lines take on a new significance.

1. 1 Aim of the Study

Within the context of Istanbul, the large-scale transportation networks, such as Metrobüs[1], Marmaray and connected metro lines, are the lifeblood in the metropolitan area. Spatial impacts of them are highly effective in terms of the property market. Finally, they transform the urban space economically and socially. What do these projects induce in urban space? Are they always associated with housing market? Do the impacts of the projects depend on the network scale? In order to understand these questions, a Marmaray based research is required to examine. The Marmaray that is a large-scale project is one of the significant network lines which connects separated suburban train systems on each continent of the city by way of under the Istanbul Stratit as a metro system. Due to a number of delays for a couple of years throughout the project, suburban trains have not been run. Therefore, the spatial impacts of the project have always been diverse over time. It has both added and lost value in the housing market within noticeable effects (Mathur, 2008; Mulley, 2014; Levkovich, Rouwendal and van Marwijk, 2016) and has changed the spatial matrices throughout the construction period. Besides, the Marmaray is identified as a mega-project with a remarkable budget that had been dreamed throughout the time to realise. Such kind of a project is directly associated with urban space since it affects and transforms the space itself. In order to understand the importance of the spatial impacts of the infrastructure based on the urban transportation, this research seeks to answer the research questions given below:

- Does the urban infrastructure transform the urban space?
- Is there a relation between the Marmaray Railway System and the properties? If there is, how does this relation impact the property values?
- Do the profiles of neighbourhood residents change through implementation of the Marmaray?
- In what way are the impacts analysed and how are these findings represented?

By reviewing the literature and doing a comparison between findings of case-year studies, it is aimed to answer the questions.

[1] Metrobüs is a bus rapid transit system using a special and separated route in the middle of D-100 highway in Istanbul. The system connects the Asian and European parts of Istanbul by crossing the Bosporus Bridge within a long-distance line.

1. 2 Scope of the Study

Since the main idea is based upon large-scale urban transportation projects, the analysis is carried out within the line of the Marmaray case in order to comprehend the asked research questions. The reason for selecting the Marmaray as a study case is that this project generates different feautures than the other transportation projects in Istanbul since it interconnects the railway systems separated by a geographical threshold called the Istanbul Strait, and located onto two different sides of the city, through a long-distance mobilisation. Such a project, inevitably, changes the matrices of space and time. Within this context, in order to determine the scope to analyse spatial changes due to those projects, the research is delimitated on the Marmaray case as a transportation project in Istanbul, in spite of the fact that large-scale projects are inclusive of a number of transportation projects in Istanbul. It affects physical and social environment such as dwelling size, dwelling type, produced number of units, ownership patterns and so forth. However, in this study, the research is held through property values and social profiles of dwellers. Consequently, the main aim of this research is to shed light on the spatial impacts of urban infrastructure projects on the housing sector and provide a panoramic view of socio-spatial changes due to the projects. Inevitably, other urban transportation projects which have big budgets impact the urban land, however, the focus of the research will be on the Marmaray project. By this way, it is aimed to understand socio-spatial changes based upon the Marmaray.

The system runs from Halkalı to Gebze. So, five-stations are contained in the border or Kocaeli Province. In this research, range of analysis in the context of train stations is limited within the border of Istanbul. Therefore, five stations are excluded from the analysis since they belong to Kocaeli province: Çayırova, Fatih, Osmangazi, Darıca and Gebze. Rather, the range of analysis includes the stations from Halkalı to Tuzla.

1. 3 Data Source

The value in the housing market bears on the spatial impacts of the urban transportation projects. These impacts, in this research, are examined within the context of standard land value (*rayiç bedel*) (TL/m²). According to the Turkish Tax Procedural Law (VUK)[2]

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[2] The law text is able to be reached through the shared link:

duplicated article 266, current value is defined as "purchase and sale value of an economic asset in the valuation day". Turkish Language Association (TDK, 2020) also defines current value in its online dictionary as the "market value". In substance, the land value is the market price of the properties that is determined by the valuation committee consists of admission officials. It is announced by the relevant municipality. The determination committee establishes and announces the land values every four years based on streets (Kurt, 2018, p.79). Since validly existing data of the standard land values comprise the period of 2018 to 2022 which is announced in 2018, the data that belong to 2018 are sought to analyse. In order to compare the multiplied data, land values of 2014 and 2010 are also decided on for this research. Rate of increase between the years of determinations is equal in the relevant city based upon economic factors. Selected years in this study accord with the case study of the Marmaray. 2010 is the year when the suburban trains are operated while they are not run but only first phase of the Marmaray is run in 2014. Even though the Marmaray project comes on stream in 2019, the valuation in 2018 is expected to show an increase due to the expected opening launch day of the project. In this case, it is expected that the effects due to the absence of the suburban train systems will be displayed more than the effects due to the construction of the Marmaray Railway system.

Further, it is also expected to explore the socio-economic profile changes based on level of income in spatial context. Due to the absence of detailed information on the data of level of income, data of standard land value are supposed to show the features and changes of spatial distribution patterns of different status groups (Güvenç and Işık, 1997, p.154). Determined current land values indicate the valuation of fixed properties of every streets per square that specifies the minimum purchase and sale value of the properties (Orhan and Sarıoğlu Erdoğdu, 2019, p.504). It is possible to analyse the dwellers' income profiles since the current land value is a determinant of property tax and factor affecting the renting market. In this case, there are two options for being a dweller. One is to be an owner-occupied property and the one is to be a tenant. In case the dweller is a tenant, the tenant is supposed to afford the rental prices. In case the property is used by owner-occupied, dweller has a potential budget in terms of changing price rates if s/he sells the

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< https://www.mevzuat.gov.tr/MevzuatMetin/1.4.213.pdf >, accessed on 12.01.2020

property. Thus, standard land values would be one aspect of understanding the profile of dwellers. Therefore, standard land values, in this research, are associated as a spatial indicator that shapes and changes the space itself and its users.

1. 4 Methodology: Delaminating the Complex Data of Urban Landscape

Collected datasets are extremely large and they are composed of thousand cases where the multi-layered data are accumulated. Understanding the variety of standard land values together with populations and length of streets of relevant areas requires a deep statistical analysis. For this reason, the analysis has three steps: standardisation of multi-layered data; clustering the standardised data, and visualisation of clustered data (Figure 1.1).

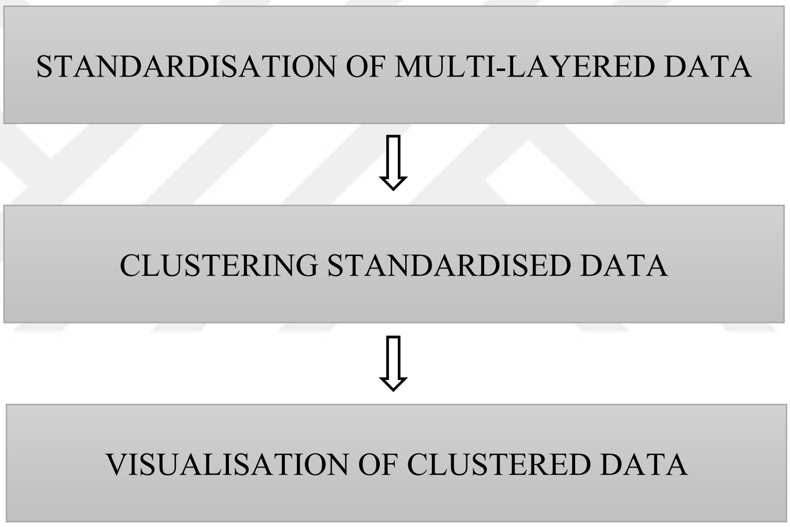

Figure 1.1. Steps of the analysis

Data standardisation is a process where the structure of disparate datasets is converted into a common data format. A standardizer dissociates the different components of data (e.g. name, type, initials, titles) and then rearrange those components into a canonical representation (Loshin, 2009). In this research, collected data are consisted of standard land values and population data as well as the length of the streets in which it is indicated two different datasets. Therefore, the statistical methods, given below in turn, are used for data standardisation of neighbourhood-based analysis[3]:

$$Ps = \frac{P}{\sum P}$$

where P is population and Ps is population share for the neighbourhood-based analysis;

$$Vw = \overline{V}\ x\ Ps$$

where Vw represents average standard land values weighted with population and $\overline{V}$ represents average land values;

$$Vd = \overline{V} - \sum Vw$$

where Vd is the deviation of average standard land values of the neighbourhoods from weighted average;

$$v = \frac{\sum Vd^2}{n}$$

where v is the variation of the analysis and n is the number of analysed neighbourhoods;

$$Sd = \sqrt{v}$$

where Sd represents the standard deviation. From this point forth, final step is to find $Zscore$ that represents the standardisation of datasets of both neighbourhoods and streets:

$$Zscore = \frac{\overline{V} - \sum Vw}{Sd}$$

Willingness to walk from the railway stations is 1-km as it is accepted in this research. Besides, it requires a wider area to compare the areas and explore the differences. Thus,

[3] The way to analyse and standardise the complex datasets is offered by Prof. Dr. Murat Güvenç.

for the street-based analysis, train stations-centred 2-km radius area are specified in order to determine the streets to be included into the analysis. So, the streets in every neighbourhoods that the circle touches are taken into the analysis.

The statistical methods, given below are used for data standardisation of street-based analysis:

$$Ls = \frac{L}{\sum L}$$

where L is length of street and Ls is length share for the street-based analysis;

$$Vw = \overline{V}\ x\ Ls$$

where Vw represents standard land value weighted with length and $\overline{V}$ represents land values;

$$Vd = \overline{V} - \sum Vw$$

where Vd is the deviation of standard land value of the street from weighted average;

$$v = \frac{\sum Vd^2}{n}$$

where v is the variation of the analysis and n is the number of analysed streets;

$$Sd = \sqrt{v}$$

where Sd represents the standard deviation. From this point forth, final step is to find $Zscore$ that represents the standardisation of datasets of both neighbourhoods and streets:

$$Zscore = \frac{\overline{V} - \sum Vw}{Sd}$$

District	Neighbourhood	GIS-ID	Average Value	Population	Population Share	Weighted Value	Deviation	Deviation Square	Zscore	**Observation**	**Class**
Bakırköy	YENİMAHALLE MAH.	40190	374	7100	0,03239864	12,12519108	-404,15	163333,45	-1,189858009	**40190**	**1**
Bakırköy	OSMANİYE MAH.	40188	398	24018	0,109598668	43,59417476	-380,63	144881,80	1,171064349	**40188**	**2**
Bakırköy	KARTALTEPE MAH.	40197	439	38362	0,175053047	76,86092036	-339,32	115140,21	1,292687291	**40197**	**2**
Bakırköy	ZUHURATBABA MAH.	40198	452	22315	0,101827557	45,98636032	-326,79	106788,54	1,329600856	**40198**	**2**
Bakırköy	SAKIZAĞACI MAH.	40191	557	8631	0,039384882	21,94432963	-221,22	48937,78	1,640402193	**40191**	**3**
Bakırköy	ZEYTİNLİK MAH.	40193	575	5437	0,024810057	14,25893878	-203,67	41481,95	1,692064877	**40193**	**3**
Bakırköy	BASINKÖY MAH.	40200	652	5722	0,026110566	17,01899433	-126,59	16025,14	1,919000905	**40200**	**3**
Bakırköy	CEVİZLİK MAH.	40192	668	5311	0,024235095	16,20077044	-109,91	12080,53	1,968106095	**40192**	**3**
Bakırköy	ATAKÖY 3-4-11 KISIM MAH.	40201	1038	7975	0,03639143	37,76910591	259,46	67320,43	3,055590505	**40201**	**4**
Bakırköy	ATAKÖY 2-5-6 KISIM MAH.	40194	1041	12103	0,055228274	57,49263273	262,60	68961,21	3,064843498	**40194**	**4**
Bakırköy	ŞENLİKKÖY MAH.	40199	1086	27269	0,124433594	135,1702825	307,89	94795,73	3,198167083	**40199**	**4**
Bakırköy	YEŞİLKÖY MAH.	40189	1140	23972	0,109388761	124,6724713	361,32	130554,94	3,35548606	**40189**	**4**
Bakırköy	ATAKÖY 7-8-9-10.KISIM MAH.	40196	1202	22211	0,101352985	121,8262885	423,60	179440,92	3,538849073	**40196**	**4**
Bakırköy	ATAKÖY 1.KISIM MAH.	40202	1205	1686	0,007693536	9,270711173	426,60	181991,54	3,547681475	**40202**	**4**
Bakırköy	YEŞİLYURT MAH.	40195	1377	7033	0,032092907	44,20415815	598,99	358783,78	4,055194098	**40195**	**5**
				219145		778,39533		1730517,97			
							Variance	115367,8644			
							Standard Deviation	339,6584526			

Figure 1.2. An example of neighbourhood-based stratification.

Following the completion of standardisation process of both standard land values and population data, further applications are still needed. One cannot simply be sought without simplifying the extremely large data. Therefore, second step of analysis is occurred by the method namely “Agglomerative Hierarchical Clustering” (AHC). Hierarchical clustering is an algorithm merging, nesting and finally clustering the groups of patterns through representing the dendrograms (Table 1.1) (Jain, Murty and Flynn, 1999). The clusters are generated according to proximity of data elements where proximity is determined by the similarity (and dissimilarity) of clusters (Figure1.3). As one can see, dissimilarity percentage increases in case the number of clusters increase. However, if the number of clusters are diminished, then the dissimilarity percentage between the clusters decreases. Thereafter, clustering process is performed by merging the most similar patterns (Bouguettaya *et al.*, 2015). By this way, it is aimed to observe the change of distribution of weighted values. AHC analysis is done on program “XLSTAT-2020” that is an addition of Excel.

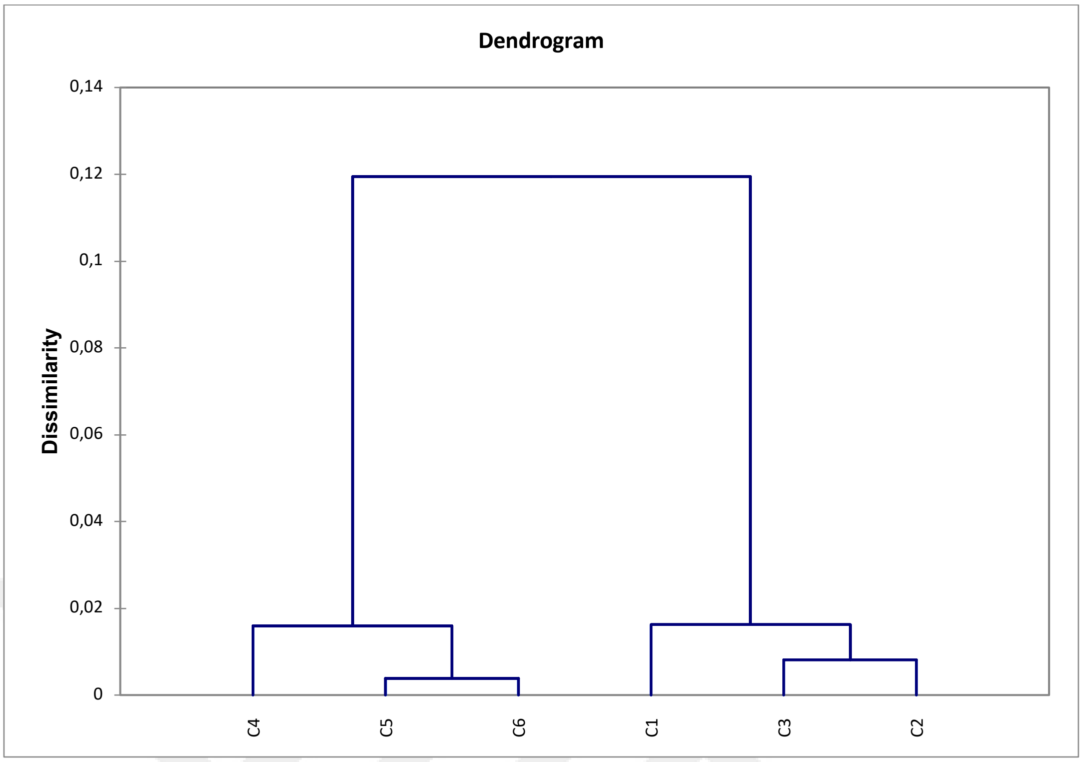

Table 1.1. A dendrogram chart representing hierarchical grouping of 6-inputs according to their similarities.

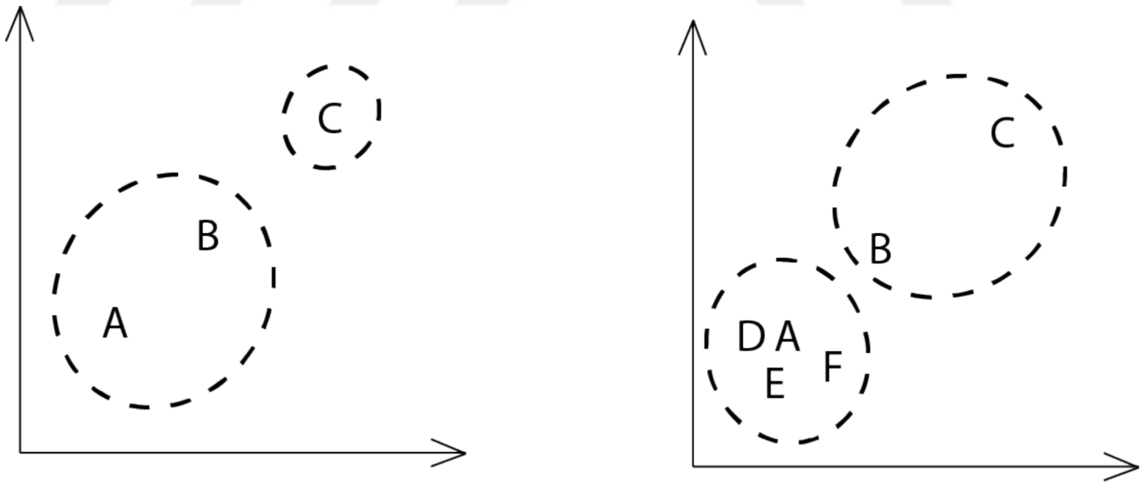

Figure 1.3. Classifications according to locational similarities.(Jain, Murty and Flynn, 1999, p.273). A and B are more similar than A and C according to their locations (left). After inclusion of D, E and F, B and C becomes more similar than A and C according to their locations (right).

The following step of the research is the visualisation of clustered data by using a geographical information system (GIS) programme, known as QGIS. GIS enables the spatial knowledge to be displayed on the map. The content of spatial data with respect to geographic attributes have improved rapidly in the past years and it is expectative that development of the spatial data will be the focal point in near future (Goodchild, Yuan and Cova, 2007; Fischer, Scholten and Unwin, 2019). GIS which is integrated with spatial data, in this context, comes into prominence in order to represent and understand the spatial dynamics through mapping. GIS, in general, can be defined as the ability in order to collect and analyse data so to represent on the map. The map is a way for conveying "spatial knowledge" as a model (Altınkaya, 2016). The combined use of these techniques resulted in mapping by GIS would provide significant patterns in order to understand the case study in the context of evidence-based spatial analysis.

Interpretation requires a classification of findings (Figure 1.4). Therefore, for three-case-based years (2010-2014-2018), firstly general overview of standard land values in the district-scale is held. Selected districts are determined in reference to the line that the Marmaray railway system passes through. In this phase, the neighbourhoods that are located in the border of relevant districts are analysed. Second step is to observe the selected districts separately for the purpose of understanding of neighbourhood hierarchy, which means order of classifications, within the border of districts. Last but not least, standard land values of the streets are visualised to understand the change due to the implementation of Marmaray. Selection of streets are based on the neighbourhoods where the Marmaray railway system passes including the surrounding neighbourhoods of the line.

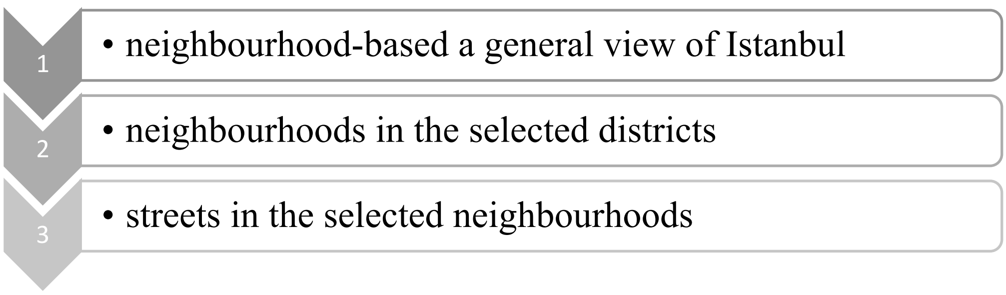

Figure 1.4. Classifications of findings

1. 5 Structure of the Thesis

After a brief introduction including the methodology of this study, in the next chapter, urban network and infrastructure are conceptualised while following chapter voices the rent theories in the light of location and characteristics of built environment. After studying the qualitative and quantitative effects of urban improvements on housing sector, brief urban history of Istanbul in the context of urban transportation and development are made noises. It is finalised by mentioning the Marmaray railway system and its effects on the relevant topic through visualised maps.

2. CONSEPTUALISING THE INFRASTRUCTURE NETWORK

The ecological effect of studying boring things (infrastructure, in this case) is some ways similar. […] Study a city and neglect its sewers and power supplies (as many have), and you miss essential aspects of distributional justice and planning power. (Latour & Hermant, 1998 as cited in Star, 1999, p.379)

2. 1 Urban Network Theory and Infrastructure

Monocentric approach to the city would fail to satisfy to understand the structure and the dynamics of it. Rather, considering a city within multi-entities (networks) would provide rich contents. In other say, cities should no longer be considered as separated from networks since it is an interactive process (Pflieger and Rozenblat, 2010). So, they can be considered as the "*juxtaposition of networked entities*" (*ibid*, p.2724). What is a network? According to the Oxford English Dictionary, the network is "a complicated system of roads, tubes etc. that cross each other and are connected to each other". The network is also explained as "a closely connected group of people, companies etc. that exchange information i.e. communications/distribution network and a number of computers and other devices that are connected together so that equipment and information can be shared" (Wehmeier *et al.*, 2006, p.1023). Network has constantly been a notion in the literature that is attributed to space and time in the city context.

Exchange network has always been sustained between, in turn, villages, towns, cities as well as countries in the global context throughout the history (i.e. food, goods, products, labour force, innovation, technical and social information including cultures, images, scholars) (Mumford, 1961; Clark, Owens and Smith, 2010). Therefore, social and physical features of one city hinges on other cities as well as those of other cities are linked to others. Cities, in fact, come into existence only through networks which generate them. By Castells's words, our understanding would be enriched in this context: " […] *places do not disappear, but their logic and their meaning become absorbed in the network*" (Castells, 2009, p.443). Further, he illustrated his statement with the example of the business centre. The business centre arises from the infrastructures such as communication and telecommunication systems, office spaces and information-profit generating systems (ibid, p.431) while the business centre is not in existence only by its physical structure, but its organised network systems (Tarr and Dupuy, 1988). In the city scale, those which exist in the city as a network, constantly generate the city. Urban systems are the one that characterise and reproduce the city.

Urban systems are the lifeblood of cities. Besides, infrastructural urban networks are the systems which are the base for a modern life and characterised urban history (Lorrain, 2005). Critical connections between infrastructure networks and contemporary urbanism have generated weighty debates by many theorists in many disciplines such as sociology and urban planning. Dupuy, in this context, is one of the main theorists sparked the debates about this issue. To him (1991, as cited in Graham (2001, p.8)), a critical approach to networked infrastructure is a powerful and dynamic way of seeing the contemporary urban spaces. The term "infrastructure" contains transportation, telecommunication, water supply, sewer and energy systems as well as roads, bridges, tunnels and so forth. Although infrastructure networks are constituted due to public needs, the infrastructure goes beyond its technical meaning in serving to the needs. They mediate to "define, shape and structure the very nature of cities", and, indeed, of civilisation (Graham and Marvin, 2001, p.30) including to establish social relations between agents and hierarchy in spaces by their visible and invisible beings.

The growth and development of urban region as social and physical aspects is considerably correlated with infrastructure networks what generate interurban networks as well. Besides, these systems are complex due to their multi-level interdependencies (Bretagnolle and Pumain, 2010). The connection between planned spaces is sustained by this network complexity. Urban form is the one that contains complexity in itself and is constituted by several factors. Dempsey *et al*. (2010) offered five factors that create the urban form in a category: density, housing-building type, layout, land use and transport infrastructure (Figure 2.1). On the one hand, they attributed the infrastructure factor to the transportation systems since the research they conducted was based on only developed countries, not developing ones. On the other hand, they mentioned that infrastructure networks (roads, water and energy systems etc.) are also important to shape the urban form in developing countries.

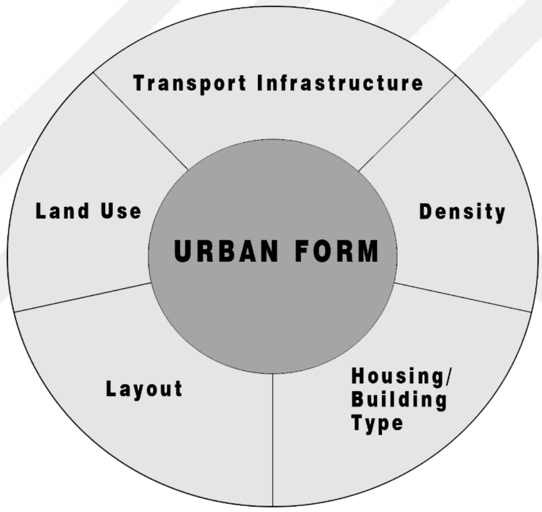

Figure 2.1. Five factors that create the urban form. *(Dempsey* et al. *(2010))*

Urban space has been characterized by infrastructure networks throughout the modernisation and rationalisation process, for example, aims of Hausmann's city plans in Paris; suburbanisation development of the European cities; and poly-centralisation. As much as infrastructure networks become "*unbundled*" and diffused, planned and built urban spaces are inclined to be "*re-bundled*" (Graham and Marvin, 2001, p.223). To illustrate, the twentieth-century modern planning trends has been built upon the functional separation of spaces, such as separation of work, housing and other functions in which monocentric cities appeared. Technological systems and infrastructure networks, however, have reproduced the space by multiplying the urban centres (Figure 2.2) including sprawl of urban growth.

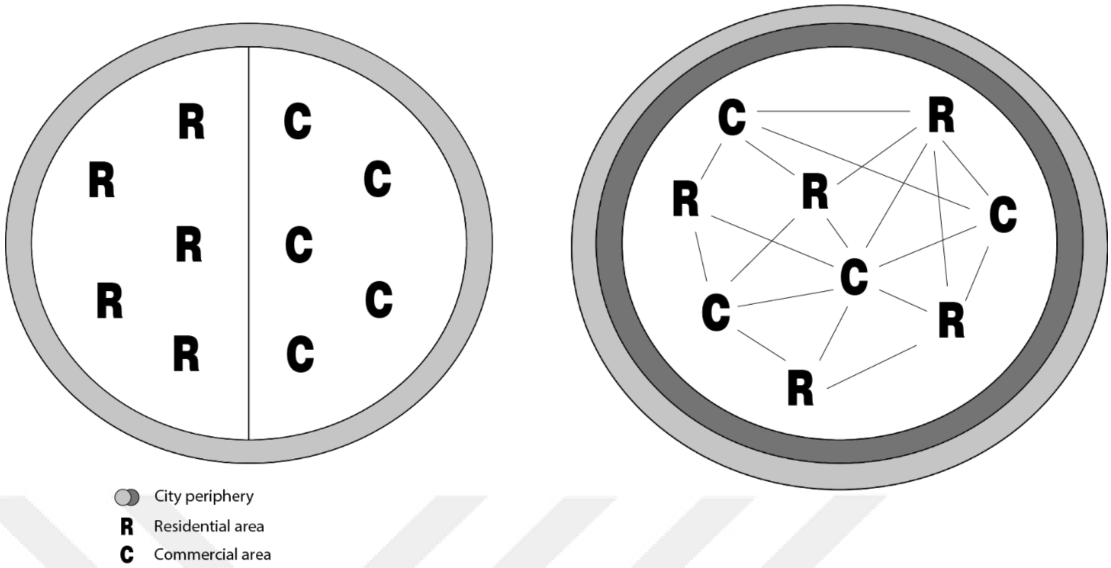

Figure 2.2. The relationship between network and city.

The relation between urban sprawl, decentralisation and transportation systems is based on a non-negligible synergy. Stough (2008, p.30) attributed the relationship between urban sprawl and decentralisation of the metropolitan area to a diverse set of forces based on mobility systems. According to him, the factors such as extensive highway systems which reduce the transportation costs to the outer city locations, lower land costs on the periphery of the city and easy accessibility to those areas create the causal links in rapid spreading of the metropolitan area. However, his statement was applied for US citizens in US cities. Apart from vast amounts of American cities, railway systems are one of the main means of transports and become the "city-maker" in European cities in which inter- and intracity transportation in human and goods mobility is sustained. Further, the railway system is not only a transportation system to sustain mobility, but also an inseparable organ of the city which also produce and reproduce the city including its dwellers and everyday life in social and physical aspects. Urry (2007) exemplified this relation as a process of reconstitution of the city and the things exist in the city. He described as:

> *[…] re-ordering of times, spaces and sociabilities that the railway system brings about as a precondition of its expansion. […] innovation the railway system constituted, re-ordering the counters of time, space and everyday life (Urry, 2007, p.92)*

In brief, among the networks, the railway transportation is one of the systems that characterise the city and existences in the city by interconnecting the different scales in different distances within a multiple network. As the re-determiner of time and space distances, railway network builds a new physical and social environment in the city by changing the benefit matrices and has ability to dominate the urban space. This, no doubt, alters the city environment. Thus, one of the ways to observe the tangible effects or alterations of the railway systems is by investigating the housing systems, in particular real-estate market.

Although there is no definite and universal urban "impact" due to urban infrastructure based on network projects (Graham and Marvin, 2001), these projects change the spatial priorities in the built environment and its members. In the free-market economy, the real estate market offers a diversity of property values. Although the property values become diversified due to several factors, the urban transport infrastructure becomes a parameter that changes the benefit matrices rapidly based on property values. The networks between the projects and the urban space are closely bound up with social, economic, political and cultural determination (Tarr and Dupuy, 1988). Besides, due to the changing property values, socio-spatial features of places including residents are influenced by the construction of transportation projects. This often results with displacing of households and disappearing of existing communities (Orueta and Fainstein, 2008; Patel, Sliuzas and Mathur, 2015). In consequence, Polarisation of socio-spatial aspects through changing property values and influencing the households in terms of their income distributions are formed. From this point forth, conceptualisation of property values concerning with network mobilities and urban dynamics would provide a deep understanding.

2. 2 Characteristics of Built Environment

In the planning schools as well as by the researchers and the policymakers, it has always given weight to urban location analysis for the improvement projects. Considerable attention is paid on extensive issue of how urban investment projects serve a function in urban form and urban property values (Dziauddin, Powe and Alvanides, 2015, p.3). The improvement projects increase or decrease the desirability of the area. In the literature, even though, the studies focus on mainly the positive effects of the projects by increasing desirability as well as quality. However, there are also some researches in which the negative impacts are found caused by the improvement projects. In this section, the effects of the urban transportation projects on the housing sector are theorised including analysing the empirical studies which are given in the literature.

Housing sector including urban land values is not homogeneous. They are not affected by a single-external factor. Rather, wide-ranging multi-layered factors impact them. It is implausible to reduce every single-external factor. However, it is obvious that transportation improvement projects have a significant and dominant position among the other factors regarding their influence quantities. Understanding and illustrating the impacts have always become an issue for value capitalisation. In this context, earlies works in the theories of classical economics on agricultural land use, economic geography and rent are theorised by Adam Smith, David Ricardo who critiqued and later on built his theory on the basis of Smith's arguments and Karl Marx who developed the theory of rent through a comprehensive critique of Ricardo's theories.

In his work "Wealth of Nations" published in 1776[4], rent, said Adam Smith, is a surplus. According to his proposal, the good and fruitful land that can be possessed are limited. Within the bounds of limited possibilities, a surplus which is named as "rent" is offered if the cost of production is less than the price of the production of the land. Thus, he suggested that the reason of high and low price is caused by high and low wages and profit where the high and low rent is the effect (Lackman, 1976; Kurz, 1978). Ricardo, took it a step further where he consistently theorised the rent issue through his famously known work, published in 1817[5]. In spite of the fact that Ricardo developed his doctrine in regard to Smith's notions offered in Wealth of Nations, he, however, criticised some of Smith's suggestions. Ricardo said that Smith made no distinction in his economic arguments between marginal and intra-marginal productions (Macdonald, 1912, p.567). Smith's understanding of rent is built upon the lands where are cultivated the same products, pay rent. So, Ricardo's distinction between intra-marginal products in different lands filled the gap missed by Smith. Consequently, Ricardo attributed his theory to the

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[4] Adam Smith (2010). *The Wealth of Nations: An Inquiry into the Nature and Causes of the Wealth of Nations*. Harriman House Limited. [1776].

[5] David Ricardo, (1817), *On the Principles of Political Economy and Taxation*, published by John Murray. In this book, he mainly proposed the relation between change of land rent and population increase in the context of fertility of agricultural lands.

notion of diversification of fertility of lands in the context of reproducible commodities. According to the Ricardian approach, rent is what remains from the total farm revenue including production expenses. His words are to illustrate:

> *Rent is that portion of the produce of the earth, which is paid to the landlord for the use of the original and indestructible powers of the soil (Ricardo, 2004, p.39).*

He drew attention with an example of settlement in a new country: when the first settlements occur in a new country/location, firstly more fertile lands and those where located close to the market, are chosen for cultivation. These lands, in fact, are limited. Following an increase in population, new lands are demanded to settle and to go under cultivation. Therefore, the pieces of land are portioned out and commodified in turn their productivity and production cost. This results with a divergence of quality of agricultural production, cost of production and cost of labour. Ricardo assumed that under the competitive equilibrium, each produces have the same cost due to diminishing productivity. Besides, the same price, he supposed, should be equivalent to the production costs of the most unfertile land. In this case, his theory indicates that the lands that have greater features in point of fertility and go into production before those start production lately will have a greater income more than the cost of production. He offered this surplus as "differential rent" (Table 2.1) (Lackman, 1976; Kurz, 1978; Du, Hennessy and Edwards, 2007; Bidard, 2014). Later on, the theory of differential rent was reshaped as "the concept of absolute rent" by Marx. [6]

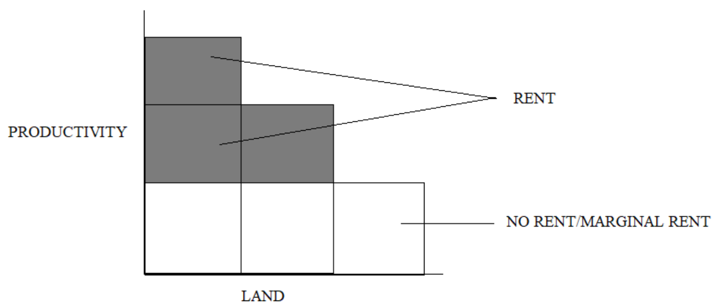

Table 2.1. Ricardian Differential Rent Table

[6] Özdemir Sarı, Ö. Burcu. CRP 341-Urban Economics lecture notes, METU, Department of City and Regional Planning.

Karl Marx developed his theory of rent[7] through a comprehensive critique of Ricardo's proposals, but he, in fact, did not propose new solutions on all critiques he did on Ricardian approach (Bryan, 1990). One of the main distinctions between Marxian and Ricardian rent theories is that Ricardo assumed rent based on natural betterness while Marx distinguished rent issue between as natural- and human-produced. Also, unlike Ricardo, he improved more than one rent theories by adding Ricardo's rent theory on. Despite the fact that he agreed with the Ricardian approach to rent of natural fertility, however, he criticised his concept of rent falling short due to the principles of capitalism. According to Marx, the fertility of the land is not only advance as natural betterness for rent but also the location of land, issue of private property and supply of things also matter for establishing rent (Ball, 1985). What is the distinctive feature of Ricardian and Marxian concepts of rent is that Marxist understanding of rent is based on the private property what Ricardo missed. Marx theorised the notion of "absolute rent" in which the rent is owned to the landholder in the case where the lands are privately possessed. In this case, without any necessity of overproduction or fertility between intra-marginal lands, absolute rent belongs to the landholder. Further, Marxian understanding of rent also suggested "monopoly rent" to comprehend the products and properties which do not meet the demand of market (Harvey, 1974; Fine, 1979; Ball, 1985; Bryan, 1990). In other say, in the case of a limited level of reproducible or unreproducible products, demand is not met sufficient supply which results with a rise in the value of supplied things in the market. The rent of urban land, in this context, can be attributed as monopoly rent since the lands located in favoured places and cannot be reproducible have greater value than those are marginal ones. Thus, the rent of lands in favoured places would be named as monopoly rent, according to Marxian understanding.

Despite the fact that most of the classical economists worked on the issue of acquisition rent from land, however, some of them also contributed the literature by their understanding of location matter of lands in relation to monopoly rent. In this case, one of the first studies on the relationship between location and the land value was given by

[7] He theorised his proposals in his work "*Das Kapital: Kritik der politischen Ökonomie*" Volume I published in 1867 and Volume II and III published in 1985 and 1894. (Translation: Capital: A Critique of Political Economy).

Johann Heinrich von Thünen.[8] His primary concern is built upon variations of agricultural land values and the use pattern existing in his time (Sinclair, 1967, p.73).

According to Sinclair (1967), von Thünen offers that the agricultural land use pattern is based upon “the competition”. This competition is controlled by economic rent which is a return from the land. At this point, accessibility to the marketplace from the agricultural land and the transport costs become the determinant of variation of the land values. Therefore, as von Thünen expresses, the distance function explains the land value difference as shown in (Figure 2.3). It depicts that the more distance from the marketplace, the more transport costs are showed up since the farmers should carry the agricultural products from the production place to the market. Briefly stated, accessibility factor to the marketplace from the agricultural land becomes a significant issue to determine and compete for the urban land values in von Thünen’s theory.

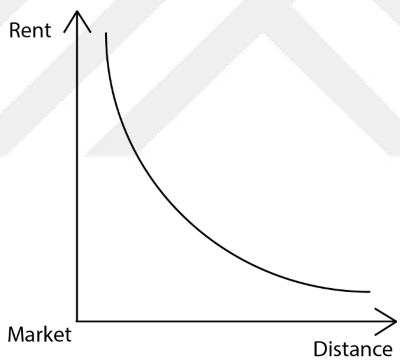

Figure 2.3. The relation between parameters of rent and distance according to von Thünen’s theory

William Alonso is one of the leading contributors among the early period of urban economists with his contributions on urban rent theory. Unlike the market place as von Thünen’s offering, Alonso’s (1964) theory is mainly built upon the proximity and accessibility to the central business district (CBD). In his theory, in brief, depending on the property location, the rent increases or decreases within the distance to the CBDs. Hence, determinant factor which defines the variation between the land values is the

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[8] J.H.von Thünen, (1826), *Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie*. (Translation: The Isolated State in Relation to Agriculture and the National Economy).

accessibility which is measured through changeable distance to the CBDs like in von Thünen's explanations in agricultural land values. However, his research addresses the "accessibility and proximity" based on the understanding of the monocentric city (Ahlfeldt, 2011). The accessibility and proximity are not the *only* issues for the polycentric cities. In the following, "gravity measures" have been discussed as an alternative to the monocentric understanding of the urban economy. Gravity measuring is theorised based on heterogeneous employment distributions of different locations (Adair *et al.*, 2000; Osland and Thorsen, 2008; Ahlfeldt, 2011). In other words, according to the main real estate price theories, more attractive points have more gravity force in terms of urban rent in comparison with less attractive points (Figure 2.4).

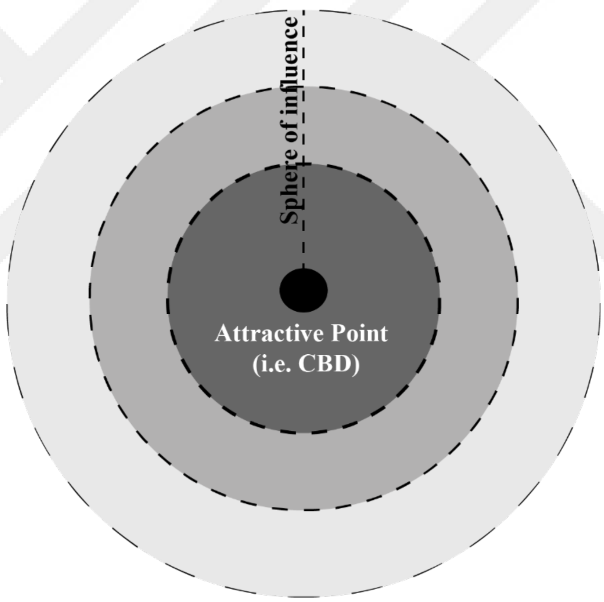

Figure 2.4. Sphere of influence and magnitude of an attractive point in terms of property values.

A location may become an attraction centre in terms of its certain characteristics (Debrezion, Pels and Rietveld, 2007). The characteristic of a location leads to an alteration in spatial demand by the agents. Hence, this process pushes the prices up or vice versa depending on the attractiveness (*ibid.* p.163). In this connection, the CBDs are considered as the attractive locations where the prices are pushed up due to certain characteristics. Hereat, CBDs can be assumed as the marketplace according to von

Thünen's theory. Therefore, the CBD becomes the central force of gravity where affects the locations gradationally in terms of proximity and accessibility. Due to its characteristics in activities, agents' demand increases for the locations close to the CBD. This may be associated with transportation costs and time spent as well since the economic activity and mobility are carried out in or around the CBDs. Furthermore, the structure of the CBDs has changed in the literature as well as in the metropolitan area. Cities, however, are not monocentric anymore. Rather, they expand within the polycentric structure. Levine (1995) explains the process of poly-centralisation as "decentralisation of jobs". Inter-suburban network changes dimensions of the land use and of centralisation. In this context, new network lines apart from the monocentric structure provide decentralization of locations.

While decentralisation process is carried out, features of built environment changes. Consequently, it may be assumed that more difference in spatial features designates more diversity among the land/property values. In other words, modelling property prices depend on many extrinsic parameters. The first parameter is the physical/structural attributes of the property itself such as plot size, quality and age of the construction (Mathur, 2008), size of rooms, number of bathrooms, average people per room (Habib and Miller, 2008) and view factor of the property (Benson *et al.*, 1998). These are the factors concerning to physical attributes of the property itself. Although, the physical attributes of the property units are significant, the neighbourhood attributes, however, are the factors which are more dominant in determining the property prices.

Neighbourhood characteristics are identified within two categories: social and physical attributes of neighbourhoods. The social attributes embody the demographic factors in the built environment and so, become one of the external factors in order to determine the property value. For instance, income and social division of the neighbourhood are the impacts on property values (Debrezion, Pels and Rietveld, 2007). To illustrate, Güvenç (2000) offers it as the social stratification for the case of Istanbul. According to him, the metropolitan area of Istanbul is divided into clusters in which those who have the same features settle together in neighbourhoods regarding their income level and origins of their roots. Furthermore, age distribution can be found as a factor which affects the average price of the neighbourhoods.[9] Likewise, type of labour force, labour force density and labour force participation rate as well as unemployment rate (Habib and Miller, 2008) and average income of the neighbourhood, educational level (Dubin, 1992; Mathur, 2008), ethnic diversity (Mathur, 2008) and the local crime rates are the external factors impacting the every property prices as well as the average prices of the neighbourhoods. In summary, the socio-economics of the area (Mulley *et al.*, 2016) and the social attributes of the neighbourhoods are of significance in determining the property values.

By the same token, physical locational attributes also matter in determining the property values and locational interest rates. In this context, physical characteristics of the neighbourhood such as type of land/property use (Haider and Miller, 2000), dwelling density (Habib and Miller, 2008) and air quality (Harrison and Rubinfeld, 1987) matter in respect to affecting the values. Additionally, every increase in average values in the neighbourhood causes also increase the values of housing units in the vicinity. More importantly, infrastructural services are the great physical attributes the most in the built environment. The desirability of the area is directly affected by the infrastructural services (Dziauddin, Powe and Alvanides, 2015) such as the water supply, sewer system, transportation and communication services. Many infrastructural services are the primary benefits for the public welfare. Within this scope, accessibility and usability of these systems estimate the attractiveness of the location.

To get back to "creating new lines in the process of decentralisation", transport infrastructure is the primary motivation to employ the network connectivity between the locations. Rail transit system is the most effective infrastructure systems among the others in which the railway transportation studies is the furthest given in the literature in comparison with other types of systems. Railway investment alters the benefit matrices of the property and location, in a larger scale. Dziauddin *et al*. (2015, p.1) offer that transportation infrastructure, particularly a railway system, is an "investment with financial returns through increased property values". Also, Banister *et al*. (2001) suggest that transportation investment as the locational externality provides additional benefits

[9] The research project mentioned above, M.Güvenç-led and in partnership with Kadir Has University-Istanbul Studies Centre, TESEV and Bernard von Leer Foundation, interconnects the age and land value parameters and visualises the outcomes. Detailed information can be found on: < http://harita.kent95.org >, accessed 30.03.2020.

together with the primary benefits. Depending on the value of proximity and accessibility to the transport investment location, in other say the railway system, the property values are capitalised. By this way, additional benefits change the locational attributes in points of proximity and accessibility from the actual location.

The magnitude of the effects of transportation services can be major or minor depending on neighbourhood characteristics, dwellers and users' profile, type of railway systems and service coverage. In the following title, it is presented the empirical researches on the effects of transport investments comparatively given in the literature.

2. 3 Effects of Urban Infrastructure

Urban infrastructure projects are one of the dominant key factors in the process of shaping the cities. Thus, the shaping process of new urban forms due to the projects go beyond the airport fence (Freestone and Baker, 2011), underground water-supply/sewer systems or transportation infrastructure. Although there is no definite and universal "impact" due to urban infrastructure projects (Graham and Marvin, 2001), these projects change the spatial priorities in the built environment such as affordable housing, distribution of spatial attributes, stratification of neighbourhoods or accessibility to the benefits.

Relationship between infrastructure improvements in the context of mega-project and urban forms in respect to the production of space is mostly built upon economic growth. A diverse range of land values is one of the outcomes of this relationship. Yet, the diverse range includes also some factors offered by Brigham (1965, cited in Kok, et al., 2014)) in which the land values are framed in urban area: "accessibility, amenity levels, and topography". Hereat, the context of housing becomes a dominant parameter affected by the land values in reaction to improvements. Housing sector provides a strong opportunity for a neoliberal turn of urban policies. Besides, through the construction of improvement projects, the dwellers' profile changes due to increasing or decreasing of land values which results with generally displacing of households and disappearing of existing communities in which new dweller profiles appear (Orueta and Fainstein, 2008; Lovering and Türkmen, 2011; Patel, Sliuzas and Mathur, 2015). The networks between the projects and the urban space are closely bound up with social, economic, political and cultural determination (see, Tarr and Dupuy, 1988). In consequence, fragmented spaces and socio-economic polarisation through real-estate economy are formed. Socio-spatial polarisation is present through rising price and influencing the low-income dwellers in reaction to improvement projects. On the other side, similar policies and practices might not produce the same outcomes in different locations.

Although, there are a considerable amount of in-depth infrastructure studies that have been attracted by scholars' attention, however, it has not been built consensus on the impacts of infrastructural improvement projects. This situation offers a diversity in the literature in which some studies demonstrate only positive impacts on urban life, whereas others do only the negative ones. Further, some researches indicate that the projects affect some individuals more than others according to their social and physical attributes while some other researches try to prove the exact opposite. From this point forth, a comparative analysis between the studies given in the literature would provide a significant insight to understand the diverse range of effects of urban improvement projects.

Research studies of infrastructure based on transportation and its impacts on socio-economic life have been given in the field of railway studies more than the other means such as bus transit systems, tunnels, highways and even informal systems. In general, research works have been given upon change of the housing and land values in consequence of improved accessibility to the transportation systems in terms of proximity. To estimate the impacts, there are a large variety of methodology between the scholars.

2. 4 Estimating the Effects of Urban Infrastructure on Housing Sector

Reviewed literature belong to the end of the century and the beginning of the millennium presents the tendencies in empirical approaches to the impact of transport infrastructure, railway systems in particular. Voit (1993) attempted to estimate the housing value associated to CBD accessibility and proximity to the transport orientation where the data was gathered over the period 1970 to 1988 in the metropolitan area of Philadelphia. He suggested that decentralization of economic centric locations such as CBD through transportation systems, especially railway systems, does not decrease the housing values. Rather, it relatively sustains uplifting the housing values. Benjamin and Sirmans (1997) stuck to the point apart from the CBD and analysed the data consisting of 250 housing units from the locations close the metro rail stations in Washington D.C. They observed and focused the effects of mass transportation availability on the housing values in relation to residential income values. The results showed that each 0.1mile decrease in distance from the metro rail station causes 2.50% increase in rent values for the housing units in Washington D.C.

Further, Debrezion *et al*. (2007) employed a different methodology for the impacts of railway stations within categorising of which provides an understanding of the distinction between residential and commercial properties. The findings from where the data were mixed which were taken from the previous studies given by different scholars, showed that the properties are affected within 1/4 mile by the local stations whereas the measured effects are available within 250 m closer to the station in the global context. Empirical findings pointed out that for the locations every 250 m closer to the station, the residential values, on an average, are 2.3% higher than commercial property values whereas the residential values are 12.2% less than commercial properties within 1/4 mile range from the railway station. Also, they offered that the dynamics of commuter railway stations are consistently more dominant compared to light and heavy railway stations. They attributed this suggestion to a wider service network of the commuter railway stations throughout the metropolitan and suburb areas.

A study for the investigation of a bus rapid transit system in Brisbane-Australia tried to grab the land value uplifts to understand how the investment projects impact the residential property (Mulley *et al.*, 2016). The writers' findings suggest that being close to the stations of the bus rapid transit (BRT) systems increases the values, in general, 0.14% and the for every hundred meters closer to the stations, it is added 0.36% or for every 250 m closer to the stations, around 2.4% increasing has been observed in the study. Further, they carried out also a comparison between BRT systems and the railway systems based on noise pollution and crime rates. They indicate that the locations around the train stations experience more noise pollution, at the same time, crime rates are higher in the locations which cause a decrease of the residential values by attributing to a study given by Bowes and Ihlanfeldt (2001). As a case of BRT, findings by Rodriguez and Targa

(2004)[10] for Bogota, Colombia also show that the rental prices of properties decrease in between 6.8% and 9.3% for every 5 minutes of extra walking time to the BRT stations.

There are also some studies exploring multiple impacts on property dynamics. One study, in this context, analysed the multilevel inputs including the influence of transportation access and aggregation of housing units in heterogenic clusters (Habib and Miller, 2008) in which 250,000 housing property transactions between 1987 to 1995 in the Greater Toronto Area. According to the study, the housing prices decrease for every additional 0.16% km from a regional transit station, whereas the prices decrease by 0.67% per km from a subway station. This finding is in accord with the ones what Debrezion offered based on the distinction of radius of impacts between commuter railway stations and light/heavy railway stations. Further, Habib *et al*. (2008) attached 2 findings in their study. First, proximity to a highway within the area of 2 km adds averagely 0.31% in housing prices. Second but not least, they also suggested that neighbourhood and housing unit attributes are the matter shaping the dynamics of the housing market such as housing conditions, crime rate of the neighbourhood and other attributes which shape the average selling price of the neighbourhood. Finally, they furnished the analysis by the suggestion of average selling price in a neighbourhood and they added that the higher average price in a given location, then the higher selling price of each housing units are eventuated. This is an interconnected function reflecting the relation of a single unit with attributes of its location.

Mathur is one of the scholars who analysed multiple inputs and contributed to housing literature. In this study (2008), exploration of housing market was carried out under 4 key variables of public infrastructure and services: transport accessibility, safety, school quality and overall quality of infrastructural services provided by the municipalities. He approached the link between housing price and infrastructural services as "travel time to the CBD locations". According to his hypothesis, the direction of change of the function in travel time is inversely proportional with housing prices. As quantitative results show that every 1% increase in travel time to CBD causes 0.0072% decrease in housing price.

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[10] Cited in "Mulley, Corinne, et al. "Residential property value impacts of proximity to transport infrastructure: An investigation of bus rapid transit and heavy rail networks in Brisbane, Australia." *Journal of Transport Geography* 54 (2016): 41-52."

However, he differentiated the low-level housing and high-level housing units and the locations. Further, he questioned the accessibility from the neighbourhoods where the low-level and high-level housing units aggregated. He proposed that it is paid low or medium wages generally in the jobs in retail sectors and low-level housing dwellers presumably labour in these sectors. Therefore, proximity to the retail jobs or transport accessibility to the services to go to the workplaces of retail jobs increase the housing values of low-level income dwellers more than high-level ones. On the other hand, due to the increase of traffic congestion and noise pollution caused by the density of accessibility to the retail jobs impact the high-level housings oppositely than the low-level ones. In brief, according to him, accessibility and proximity are the factors to estimate the impact of services on housing prices in terms of comparing low-level and high-level income housings. On the contrary, a study (Haider and Miller, 2000) showed that the environmental factors and transport facilities are not significant in the evaluation of housing prices that much. Rather, the average income of the housing units and housing attributions such as number of washrooms and bedrooms matter.

Apart from the physical attributions of the units, Dziauddin, Powe and Alvanides (2015) attempted to investigate the impacts of a light rail transit (LRT) system on housing property value in the case of Greater Kuala Lumpur area in Malaysia. The significant point on this study is that the analysis was constructed on the distinction of spatial heterogeneity and spatial autocorrelation since the housing values are affected by the heterogenic factors in spatial context. Thus, they interpreted the change of housing value not only by the transportation. Rather, they tried to observe other external patterns. For example, the complexity of the development of the metropolitan area, desirability and other similar patterns (Smith and Gihring, 2006). They offered that an LRT system can be assigned as an improvement project with “financial returns”. The economic benefit provided by this system is supplied through an increase in property values since the LRT system enhances the desirability of the area. Thus, it is expected that potential residents demand to pay the higher prices for the locations where are close to the transport facility stations (Mulley, 2014; Dziauddin, Powe and Alvanides, 2015).

On the one hand, these findings were analysed for the period of completion of the transportation service projects. On the other hand, the construction period or even a talk on a prospective project may lead to a change of dynamics of the housing market. Although there are not many, in this context, there are some studies given in the literature to understand the potentials of the future improvement projects (see, Yiu and Wong, 2005; Cotteleer and Peerlings, 2011; Levkovich, Rouwendal and van Marwijk, 2016). The consensus indicates that a public improvement project leads to an expectation either while the project is under construction or newly planning period. Therefore, changes in property values reflect the residents' expectations on increase of social welfare and "willingness to pay" more in the locations close to the development projects. In other saying, expectations of benefiting from the service opportunities are capitalised not only before the projects exist, but also well before the completion and putting into service.

Up until this point, it was tried to explain and combined the studies on urban improvement projects and their impacts on property value in a comparative way as well as the way how networks shape the cities. To understand the dynamics of urban improvement projects on housing sector, analysing the empirical researches in the literature would provide significant insights and comprise a basis for new researches. From this point forth, examining a local case study which is faster, more comfortable and has higher capacity in comparison with the old form of itself, thoroughly would enable us to broaden our viewpoint. Thus, it will be addressed the Marmaray Railway System as a case study and construct a hypothesis on the basis of its effects on the housing sector including a brief history of development of Istanbul Metropolitan Area in parallel with development of suburban railway services.

3. SHAPING URBAN MACROFORM THROUGH INFRASTRUCTURE

Daily commuting of Istanbul has always been crucial and a hot topic together with the development of the city synchronously. Many transportation projects have been implemented by the central government, municipalities and investors whereas some of the projects have been developed spontaneously through daily activities and by people from everyday life. In this chapter, a brief history of urban development depending upon urban transportation is employed. Following, the commuter train of Istanbul which will, later on, was evolved into a mass rapid transit railway system called as the Marmaray project will be examined. Finally, the research questions concerning the Marmaray and urban housing are analysed.

3. 1 Development of Istanbul in Parallel with Transportation

Istanbul has an exclusive geographical urban form oriented with hilly terrains. It lies between the Marmara Sea and the Black Sea. The integrity of the city is divided by the Istanbul strait which is called the Bosporus and the city is split up into two landmasses: European and Asian (Anatolian) sides. Besides, the historic centre of Istanbul straddles through an estuary famously known as the Golden Horn (Haliç) (Figure 3.1). Due to the challenges and complexity of the geographic structures and thresholds, mobility in the city has been consistently a problematic issue since the city started to transform from a "walking-city" to the "vehicle-city".

Implementation of ordinated transportation systems of Istanbul, where was the administrative centre of the Ottoman Empire, has been actualised with some delays in comparison with the western cities that have already started to be transformed throughout the process of the industrial revolution. By the mid-19th century, mobility has been sustained by walking, shared-little boats between the shorelines and horse-drawn transportation[11]. In this context, the city was constructed within a compact form which was split up into three main mass settlements: the historical peninsula bounded by the city walls; Beyoğlu or then famously knowns as Pera standing right across the historical peninsula beyond the Golden Horn; Üsküdar where is located the opposite shore of the Bosporus. What disrupts this integrity and compactness of the city was the geographical barriers due to the natural waterways.

Figure 3.1 Diffused urban area of Istanbul in 1916 [12]

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[11] By the mid-19th century, only the Sultan was able to ride a horse or vehicle whereas the statesmen and the senior bureaucrats were allowed to have this right to do at the following times. Lowly-enlisted civil servants were not even allowed even to ride a horse: in Engin, V. (2012), p.88 'Istanbul'da Şehiriçi Kara Ulaşımı: At Arabalarından Otomobile', in Engin, V., Uçar, A., and Doğan, O. (eds) *Osmanlıda Ulaşım: Kara-Deniz-Demiryolu*. Istanbul: Çamlıca Basım Yayın, pp. 87–103.

[12] Kuban, D. (2000), "*Istanbul Bir Kent Tarihi*", Tarih Vakfı Yurt Yayınları. quoted by (Aktuğlu Aktan and Yenen, 2012).

Apart from the shared-little boats that were serviced by the small investors, one of the breaking points of the urban form was to establish a sea transportation company (*Şirket-i Hayriye*) with scheduled services in 1851 (Tekeli, 1992). To touch on an important matter that, in a report that was prepared to estimate the positive and negative aspects of this company before its establishment and made by Fuat Pasha and Ahmed Cevdet Pasha revealed the fact that "a company that provides the regular services on sea transportation is essential since the settlements along the seashores of the Bosporus are only used in the summer terms while the residents should move in the city centre throughout the other seasons" (Engin, 2012a). Therefore, according to their observations, enabling residents to settle in the estates located along the Bosporus is the way possible with a regular sea transportation by steamboats. Interestingly enough, urban form of the city has begun to develop toward the north side of two land-masses (see, Figure 3.1) through an attraction increase of the fishing villages due to Şirket-i Hayriye which increased crowds in the Bosporus (*Istanbul Ulaşımında 50 Yıl*, 1974). Moving the Sultan's palace out from Beşiktaş toward the shoulder of Yıldız Hill was also one of the reasons that transformed the Bosporus into the recreation and built-up area while the settlements in the walled city and Pera started to expand toward the north (Aktuğlu Aktan and Yenen, 2012, p.101). Although the initial ferry services have been carried out along the Bosporus, new lines, in the following, have been established in-between Sirkeci-Adalar, Sirkeci-Pendik and Sirkeci-Ayastefanos (Yeşilköy) (Tekeli, 1992, p.19). The growing urban form on the bands that were assisted by the sea transportation along the Bosporus and toward the seashores of the Marmara Sea was constituted disconnectedly as low-density settlements. In this context, the improvement of land transport arose as the way to develop the urban form. The need for land transportation led to the establishment of horse-drawn trams in the city. The first line completed and started to run between Azapkapı and Beşiktaş in 1872 while the new lines were implemented in the following times. Unlike the ferry routes, the general tendency indicated that distribution of investments of tram lines was determined depending upon the population and mobility density (Çelik, 1993, p.93). It is a fact that the distribution of horse-drawn tram lines has not shaped the urban form dominantly in Istanbul, but the commuter train, on the other hand, noticeably has done it in a rational way.

The railway transportation was what represented the modern world during the 19th century. It changed the understanding of space and time including perspectives in urbanism and imagination of space (Toprak, 2003). The Ottoman Empire was a latecomer to implement the railway projects due to economic and technologic issues. However, two projects were proposed and introduced in the following times during the second half of the 19th century: The first one was to connect the centre of the empire-Istanbul toward Europe namely through "Rumelia Line" that was supposed to reach to Vienna; the second project, namely "Baghdad Line" planned to make a connection between Istanbul and the Baghdad that was found far from the capital city. Istanbul has met the railway systems by the construction of these two lines.

Just after drawing up an agreement by the government and a foreign enterpriser in 1869, Rumelia Railway Line has started to run in the phase of Istanbul as a commuter railway system 15-kilometre-long from Yedikule to Ayastefanos (Yeşilköy) in 1871 (Tekeli, 2009, p.31). Despite the fact that the system has been operated well as the first railway system of the city, however, the distance from Yedikule to the city centre was long and reaching from one another caused some mobility difficulties. Finally, the railway system has been prolonged from Yedikule to Sirkeci where was the central business district. It was put into service in 1873 (Engin, 2012b, p.226).[13] Right after the opening of the first phase of the railway system toward Europe, the one connecting Istanbul to Baghdad started to be constructed in 1871. The first phase of the line 91-kilometre-long from Haydarpaşa to Izmit was put in service in 1873 (Tekeli, 2009, p.31). The line followed all along the southern seashore of the Asian part of Istanbul, in turn, Haydarpaşa, Kızıltoprak, Göztepe, Erenköy, Bostancı, Maltepe, Kartal, Pendik, Tuzla, Gebze, Diliskelesi, Tavşancı, Hereke and Yarımca (*ibid*, p.31). Practices in everyday life have been varied through introducing the railway systems east to west. Likewise the Bosporus, the southern shores of the city have been shaped by the recreation areas and zones of

[13] In order to extend the railway line from Yedikule to Sirkeci, the line had to pass through the garden of Sultan's palace in Sarayburnu area. Even though, the government and senior officers opposed the proposal of extension of railway system, Sultan Abdülaziz accepted the request of passing through the garden of his resident. Rumour has it that Sultan's response to this request was "I consent that even it can pass by on my back, if the railway system will be implemented in my country". (Translated by author). (Memleketime demiryolu yapılsın da isterse sırtımdan geçsin, razıyım). (Please find the detailed information in Engin, 2012b).

summer houses throughout history of Istanbul in which there were no permanent settlements all the year-round due to the lack of transportation infrastructure. However, the commuter railway systems provided the infrastructure for being mobile from the suburbs to the city centre. This opportunity offered the dwellers to settle along the southern seashores all year round that led to urban form to grow on the linear bands between east-west limits of the city. Finally, the residential districts that were constructed disconnectedly and dispersed due to sea transport, were intensified and compacted by the railway systems along with the Marmara Seashores (Aktuğlu Aktan and Yenen, 2012). These infrastructure-supported planned residential districts were based on the grid street plan through "the Ebniye Law" dated in 1882[14] (Tekeli, 2013, p.89). The city was identified by two main linear bands following the railway and sea transportation systems on the line of the Bosporus as the north-south axis and Marmara Seashores as the east-west axis. As a result, decentralisation of the walled city through disaggregation of dense urban centre toward the bands following the railway lines started during the second half of the 19th century.

After the proclamation of the republic and the establishment of Ankara as the new administrative centre of Turkey, Istanbul lost its substantial amount of population as from 1923. Such a radical event, inevitably, altered the spatial and social landscape of Istanbul. Even, some of the transportation companies tried to take some precautions.[15] For instance, since the regime was changed and the landlords of waterside-residents/mansions that served the empire as the senior-officers left the settlements along the Bosporus, population density and demand to use of the steamboats decreased. To withstand against the tendency of the population loss, the Şirket-i Hayriye launched a campaign within the bounds of the possibilities. This campaign offered to carry the construction products for free for those who wanted to build a building in the Bosporus and provided a free-pass

[14] The Ebniye Law is the first development plan law throughout the Ottoman Empire history which is intended for the regulation of city planning including use of lands, control of areas under the fire risk and protection of development rights (See Tekeli, 2013).

[15] Due to lose of substantial amount of its population during early years of the young republic, the dense of use of commuter trains decreased. So, the companies that run the railway systems in both Asian and European sides, proposed special tours toward to recreation areas in order to gain more passengers. In the following years, the number of passengers using the commuter lines increased (See, *Istanbul Ulaşımında 50 Yıl*, 1974, p.103).

card for three years.[16] The company also built a school in Kandilli where is a neighbourhood and some recreation areas in a different location along the Bosporus so to encourage those who had houses around there to settle all year round (Tekeli, 1992, p.21) even though the number of passengers decreased regularly.

By the mid-1940s, there was no radical change in urban landscape in terms of transportation and urban form due to the impacts of the Great Depression and WWII. During the early years of the republic, urban transportation forms majorly consisted of railway and sea transport systems like the previous century. As distinct from the previous practices, this era is known as the nationalisation of public goods and services as well as the railway systems in Istanbul. Through transferring of the railway systems to the state railway systems (TCDD), ticket prices of commuter services were discounted by 90% in 1928 (Railway system in the Asian side) and 1937 (Railway system in the European side). Through the way of discounting the ticket prices, the number of railway passengers was approximately doubled (*Istanbul Ulaşımında 50 Yıl*, 1974, p.103). There are also two matters to speak of the era lasted to 1945. Transportation systems of Istanbul are in some way related to the spectacular fires. The historic peninsula that was consisted of narrow streets and wooden houses, was burned out for many times. Disadvantageousness of fire led to streets and main roads to be rebuilt under the city planning regulations (Aktuğlu Aktan and Yenen, 2012, p.21). By this way, new tram lines were able to be implemented (i.e. Fatih-Edirnekapı line-1929) which required some arrangements such as road width and the material choice. The second matter mentioned above is to come on the stream of the public buses and taxis. Because of the Great Depression, the affordability of the cost of the taxi has changed. Therefore, the shared taxi was the offered and practised solution which constituted the foundation of shared transportation affecting the urban form in a long view (Tekeli, 2013). Likewise, the shared taxi, public bus systems were the one that shaped the city within a long run whereas it was one of the dominant characters with its considerable influence after the city was transformed into a highway-privileged form.

The distinctive feature of this era was to attempt to prepare an extensive land-use plan of Istanbul. Henry Prost, a French planner and architect, spent his years from 1936 to 1951

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[16] For a detailed information, please see, "Boğaziçinde Bayındırlık Hareketi (1936), Boğaziçi, sayı 3, Aralık 1936, p.4".

in Istanbul since the development controls and planning have lagged behind. In the context of transportation, characteristic features of namely Prost Plan proposed to make the city suitable for motor vehicles in order to compact and unite the city that sprawled along with the line services (Tekeli, 2013, p.148). For this purpose, to connect the landmasses, he proposed a double-layered tube tunnel project linking Sirkeci to Harem which was supposed to service for both motor vehicles and a railway system. Besides, the plan was dealt with vehicular traffic to give it a priority by opening new roads and the enlargement of existing ones (Merey Enlil and Kaptan, 2009, p.28). However, Prost Plan has been never involved in two of five-years-development plans, even though some points in the plan were picked.

Prost was not the only planner who proposed some regulations related to urban transportation and urban form. Prof. Luigi Piccinato who was an Italian planner and assigned as a consultant to the Development and Planning Agency of Istanbul in 1958 was an important actor at the end of 1950s. The points of Piccinato's plan that were differentiated from the previous practices were based on the proposals in the development of the urban form. His plan sought a different spatial organisation through the dissolution of a dense urban centre that has got stuck in a small determined area within a compact form and, so he opposed the radio-concentric urban form. Rather, he proposed an open and linear system within a decentralised urban form (Tekeli, 2013, p.163). He also determined that the decentralised areas had to be connected along a mainline that would unite all the urban areas around itself which was claimed that created a linear form around a mainline would control the distribution of rent (*ibid*, 196). However, due to the military coup in 1960 and turbulence of the politic system, Piccinato Plan was suspended, although the main ideas of the plan were implemented in the following years. On this exact period, massive migratory flows from the rural areas in Turkey began toward the metropolitan cities, particularly Istanbul.

Spectacular migration waves by those who were to be employed in the growing industrial zones in Istanbul put urgent demand on housing. However, the housing policies and housing supplies remained incapable to meet the housing demand which eventuated with informal settlements around the industrial zones and hold on the fringe of the city (Merey Enlil and Kaptan, 2009). Rapid growing population boosted the demand for inner-city transportation services which were not within the bounds of possibility offered by the public services. Finally, the micro-entrepreneurs appeared in the transportation sector and they supplied shared vehicles city-wide as a spontaneous solution. (Tekeli, 1992). The urban form started to naturally develop as “the oil stain” since the informal settlements were constructed in the fringes and around the industrial zones that had the gravity force in order to determine the housing distributions. Supplying the shared vehicles toward the informal residential districts to connect them to the urban centre enlarged the oil stains in the city. This era reflected the tendency increase in transforming the city into a motorised form. Interestingly enough, 1961 was the date when the first local private car was produced, and at the same time it was the date of removal of the electric tram in the European side; 1966 was also the date when the produced cars were brought to the market and removal of the electric tram in the Asian side (Alpkokin *et al.*, 2016, p.68). The policies that were held during the mentioned era changed the urban landscape revolutionary in a way to develop the motor vehicle industry and to encourage the city to transform into a highway dominant transport system.

The process of urban development within partly planning and partly without planning generated an exclusive urban dynamic for Istanbul. This dynamism provoked a bridge for the purpose of crossing the Bosporus and a beltway (D-100) to be constructed that constituted backbone of the macro-form of Istanbul.

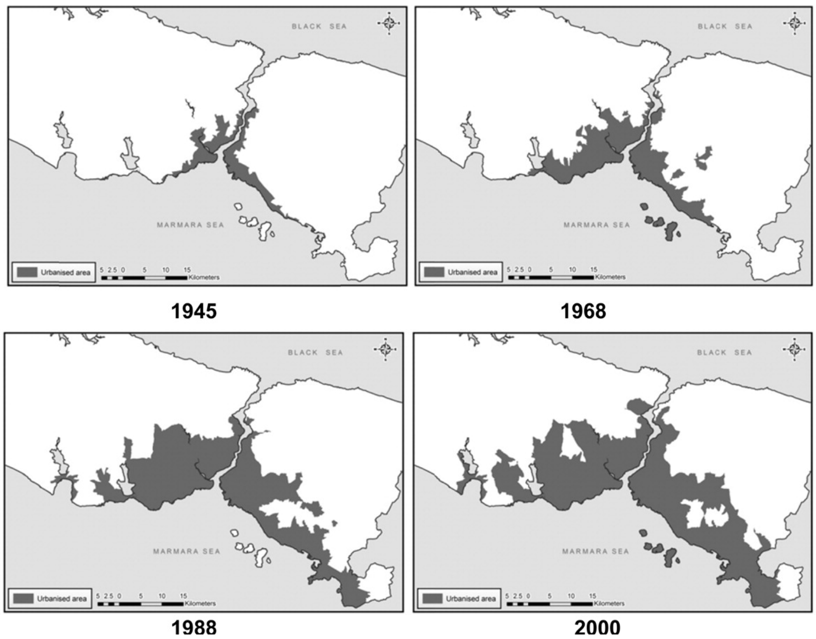

Figure 3.2. Land use changes of Istanbul (Alpkokin *et al.*, 2016, p.72)

Further, through the instalment of the second bridge over the Bosporus together with its expressways that are a part of the Trans-European Motorway (TEM), the built-up area gradually developed toward the north (Alpkokin *et al.*, 2016, p.69). Establishing the first bridge accompanying with its motorway (D-100 "famously known as E-5) increased the accessibility and it was followed by the uncontrolled growth of residential areas for the working-classes and urban poor since the unplanned development of industrial zones along the motorway corridor was carried out. Besides, the implementation of the projects changed socio-spatial geography. Güvenç (2000) stated that by the 1980s, the pattern of settlements has been affected by the E-5 motorway. He added that it split the settlements that were located on the band. The first band was by the seashores of the Marmara Sea were shared between the upper-middle-class residential areas where the land values were relatively higher due to several reasons such as accessibility to the transportation systems, landscape and distribution of income. The second band was of middle-income-class residential areas between the first band and the E-5 motorway whereas the lower-income-class residential areas were distributed beyond the E-5 since these areas composed of informal settlements.

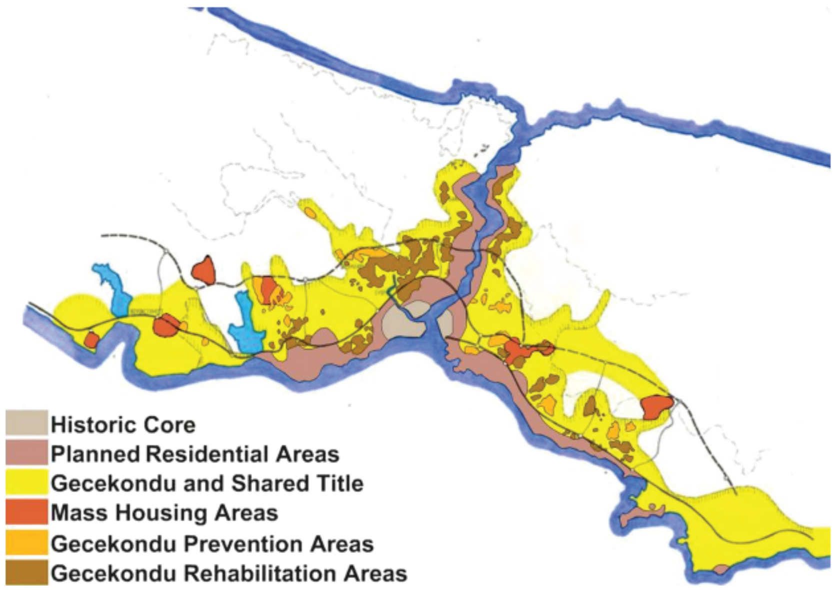

Figure 3.3. A map the legal status of residential areas by the 1990s[17].

[17] Kaptan, H. (1991), "*The development process of the service sector in the Istanbul metropolitan area: An analysis of the Büyükdere sub-region*". unpublished research report quoted by (Enlil, 2011).

Every beltway project provided spatial-attractiveness for the industrial zones to be located along the corridors through a decentralisation process what developed a mass housing demand followed by the increase of land values due to the supply-demand equilibrium. In other words, they dramatically altered the balanced distribution of urban growth matrices. To speak on the way of urban growth, different from the previous era of the construction of two bridges, the urban form has grown through the articulation of urban masses that were high-density instead of growing disconnectedly as the oil stain. The land-use master plan prepared in 1995 by the Istanbul Metropolitan Municipality supported the idea of the growth of urban macro-form as a linear and multi-centred pattern (Alpkokin *et al.*, 2016, p.69) whereas the planned linear macro-form has been disturbed by the implementation of the third bridge in the northernmost Bosporus and the third airport located by the seashore of the Black Sea.

3. 2 Transportation and Change of Property Values in Istanbul

Infrastructural projects lead to a change in social and spatial aspects of urban space throughout the history of Istanbul as much as other cities all over the world. In the context of property values, existing or lacking transportation services affect the balanced value of properties. To give an example from the history, Hüseyin Avni Şadan[18] published an article in 1942 concerning to a dramatic increase of land values. He said that introducing a tram line and making new roads affected the land values along the seashore of the Asian side. According to his examples, unit rates in the Küçükyalı Neighbourhood turned into 10.000 Lira in 1942 whereas it was 300 Lira in 1939. Also, in Caddebostan, the unit rate for the lands was 4.000 Lira in 1935, however, it increased to 90.000 Lira in 1942. He has put an interpretation on the rise of land values that capital owners invested their capitals in the estates due to the fear of the erosion of money during the war years (Tekeli, 2013, p.160). Further, another interesting case was given in Zeki Sayar's statement (Sayar, 1953). He made mention of the land speculations from Haydarpaşa to Izmit; and Sirkeci to Silivri. According to his observations, the roads namely Istanbul-Ankara and Istanbul-London Highways played major roles for the lands to be speculated since the fields were split and sold with the high prices than expected. In addition to them, as mentioned above, Piccinato also aimed to get the distribution of rent under control

[18] Please see, Hüseyin Avni Şadan (1942). "*Şehre Doğru*", Yurt ve Dünya, sayı 18, Eylül 1942.

through his linear urban form proposal including the main beltway. By this way, he expected the decentralisation of the radio-concentric city would prohibit the uncontrolled rent distribution whereas he went wrong because of the practices followed the construction of E-5 motorway. Further cases in Istanbul those were implemented or are under construction also support the hypothesis of impacts of urban transportation projects on the property values. Examined impacts of transportation projects since 2000s, for instance, implementation of Metrobüs-mass transit system(Bayram, 2010; Alpkokin and Ergun, 2012), (M4) Kadıköy-Tavşantepe Metro Line (İnanoğlu, 2014; Corum, 2020) and (M2) Yenikapı-Hacıosman Metro Line (Beyazit, 2015) have played major roles influencing the real estate market in terms of accessibility and desirability. Spreading rumours of the prospective projects before they are planned (Figure 3.4) or start their construction (Figure 3.5) are even effective for transforming the property values.

Metronun adı bile yetti, Tuzla'da konut fiyatları katlandı

İstanbul'un Anadolu yakasında bir süredir devam eden metro çalışmaları bölgedeki konut sahiplerinin işine yaradı. Henüz faaliyete geçmeyen metronun adı bile Tuzla'daki konut fiyatlarını üçe katladı.

Emlak • 03 Mart 2016 17:27

İstanbul'daki mega projeler ve altyapı çalışmaları hız kesmeden devam ediyor. Projelerin yer aldığı bölgelerde ise konut ve ticari alanların fiyatları kısa sürede artıyor. Kuzey Marmara Otoyolu ve metro projeleri ise Anadolu yakasında özellikle Tuzla'da fiyatları ulaşılmaz boyutlara getiriyor.

Metro açılmadan ev fiyatları 2'ye katlandı

2016 yılının ortalarında açılması planlanan Üsküdar-Sancaktepe metrosu, henüz hizmete girmeden Sancaktepe bölgesinde ev fiyatlarını iki kat artırdı.

İstanbul'da ulaşımı kolaylaştırmak ve hızlandırmak amacıyla hayata geçirilen metro, tramvay ve Marmaray gibi raylı sistemler konut fiyatlarını doğrudan etkiliyor.

Gelecek yılın ortalarında açılması planlanan 20 kilometre uzunluğundaki Üsküdar-Sancaktepe metrosu, henüz hizmete girmeden Sancaktepe bölgesinde ev fiyatlarını iki kat artırdı.

Türkiye Sınai Kalkınma Bankası AŞ (TSKB) Gayrimenkul Değerleme İdari İşler ve iş Geliştirme Müdürü Özge Aklar, İstanbul'da raylı sistemlerin konut piyasalarına etkisine ilişkin hazırladıkları raporun sonuçlarını açıkladı.

Figure 3.4: Prices of houses are doubled up before the metro project (Üsküdar-Sancaktepe) is realized. (left) (Milliyet, 28.11.2015)[19]

Figure 3.5: Even the name of the project is enough, prices of houses are multiplied in Tuzla district. (right) (Ekonomi24, 03.03.2016)[20]

[19] Available at: <http://www.milliyet.com.tr/ekonomi/metro-acilmadan-ev-fiyatlari-2ye-katlandi-2155203> (Accessed: 6 January 2020) –Translated by the author
[20] Available at: <https://www.ekonomi24.com/metronun-adi-bile-yetti-tuzlada-konut-fiyatlari-katlandi-13551-haber/> (Accessed: 6 January 2020) – Translated by the author

The Marmaray Mass Rapid Transit railway system is a project that was put in service much later than designated date of the project. The operations of the commuter trains of Istanbul were stopped in 2012 and the speculations in real estate market grown along with the construction process. Following chapter, impacts of the Marmaray project on the housing sector are examined after a brief history of the adverse condition of the construction process.

3. 3 A Mega-Project: Marmaray

After the millennium, Istanbul has gradually met the mega urban projects regarding to scale, network distribution and capital budget. Marmaray Mass Rapid Transit railway system is one of them constructed in the era of mega-projects. The system connects the railway tracks in both sides of Istanbul to each other through a tunnel under the Istanbul Strait (from Üsküdar to Sirkeci).

On the one hand, the project has been newly made actualised. On the other hand, the background of the project goes back a long way in the history. The foundations of the project come from the era of Sultan Abdulmecit and Sultan Abdulhamid II. Although the idea on crossing the Istanbul Strait got off the ground in 1891 during the Sultan Abdulmecit's reign, the first proposal given in 1902 in the era of Sultan Abdulhamid II (Figure 3.6). This tunnel project called as "Tünel-i Bahrî" (The Sea Tunnel), was planned to build standing on 16 carriers under the sea whereas the conditions of the mentioned era did not allow to construct such a project (Efe and Cürebal, 2011, p.721). Further, by the French engineer Ferdinand Arnodin in 1900, it was proposed to cross the Istanbul Strait through the way of connecting the railway tracks was namely known Cisr-i Hamîdi (Hamidiye Bridge) which was supposed to connect Rumeli Hisarı to Kandilli (Figure 3.7). The most important feature of this project was to band the separated railway systems together from Bostancı to Bakırköy (Yılmaz, 2012, p.194). This project was proposed to accompany with the planned bridge connecting Sarayburnu to Üsküdar. By this way, it was aimed to connect the Rumelia Railways and Baghdad Railways and to provide a direct journey from Baghdad to Vienna without any transfer.

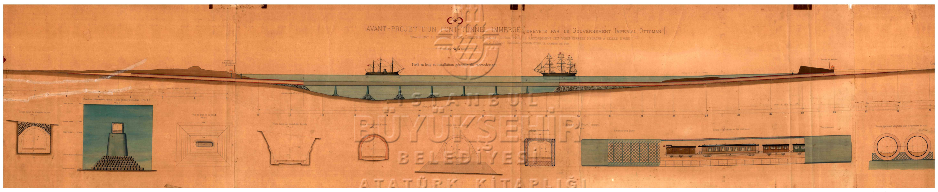

Figure 3.6 Section of proposed undersea tunnel “Tünel-i Bahrî”[21]

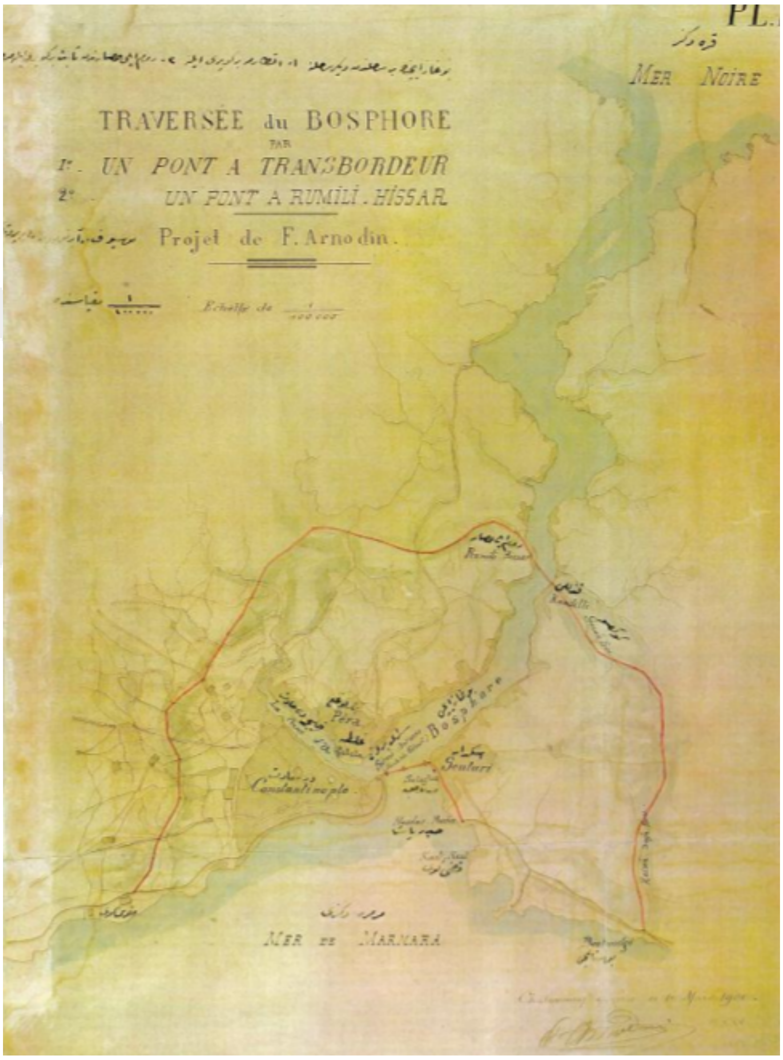

Figure 3.7. Representation of two bridges and a beltway connecting Bostancı railway station to Bakırköy railway station, proposed by F. Arnodin (*Boğaziçi'ne İki Köprü: Sultan II. Abdülhamid Han'ın Cisr-i Hamîdî (Hamidiye Köprüleri) Projesi*, 2009, p.9)

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[21] İ.B.B. Atatürk Kitaplığı Sayısal Arşiv ve e-Kaynaklar (624.193 PRE 1860 k.1/1). “*Avant - Projet D'un Pont-Tunne İmmerge, brevete par le Gouvernement İmperial Ottoman: Traversant le Bosphore entre Constantinople et Scutari pour le roccordement des voier ferres d'Europe a celles D'Asie*”, Cilt 5. Paris : Sans Librairie, 1860.

In spite of the fact that, no project was actualised for a century in terms of crossing the strait through the way going underground of the sea, however, feasibility studies have been started by the Prime Minister Turgut Özal in 1987. Initial tenders have been made in 2000 but the official process of construction started in May, 2004. The project was based on modernisation of existing commuter railway systems; renewal of the stations; and implementation of tubes under the Istanbul Strait to connect the separated railway systems. It was designated to put the system in service in different phases. In this context, the operation of the 25-km-long historical commuter railway system that has been run in the European part has been cancelled in March-2012 and the 44-km-long one in the Asian has been stopped working June-2013. Just after these regulations, initial phase of Marmaray was opened to run in the line that starts from Söğütlüçeşme to Kazlıçeşme in October-2013. Even though the predetermined date of the opening of the first phase was 2009, however, designated date was delayed for 4-years due to discovering an archeological site in Yenikapı construction area.[22] Besides, modernisation and renewal of the existing railway systems were started in 2012 and it was announced to finish the process in 24-months for the purpose of linking the railway systems to connect with the first phase. However, due to unaccounted losses in mega-budgets of the contractor companies, the systems were hardly put in service in March-2019 after 5-years than its designated date.

Figure 3.8. The route of the Marmaray[23]

[22] Available at: < http://marmaray.gov.tr/marmaray-hakkinda/ >, (Accessed: 18.05.2020).
[23] Available at: < http://marmaray.gov.tr >, (Accessed: 20.06.2020).

Speculations in property values, hence, gradually increased regarding to the long delays of the project. Redetermination of space and time matrices is inevitable through the implementation of Marmaray, as much as practices in other transportation projects. It is a fact that analysing the distribution of weighted property values is one of the ways to observe the spatial impacts of Marmaray since this project alters spatial priorities in regard to housing sector. For this reason, analysing the property values of selected time periods which correspond to process of the construction of the project would provide significant insights in order to understand the way how the Marmaray as a mega-project changes the urban landscape in terms of the housing sector. Methodology of this research is explained in Chapter 1.

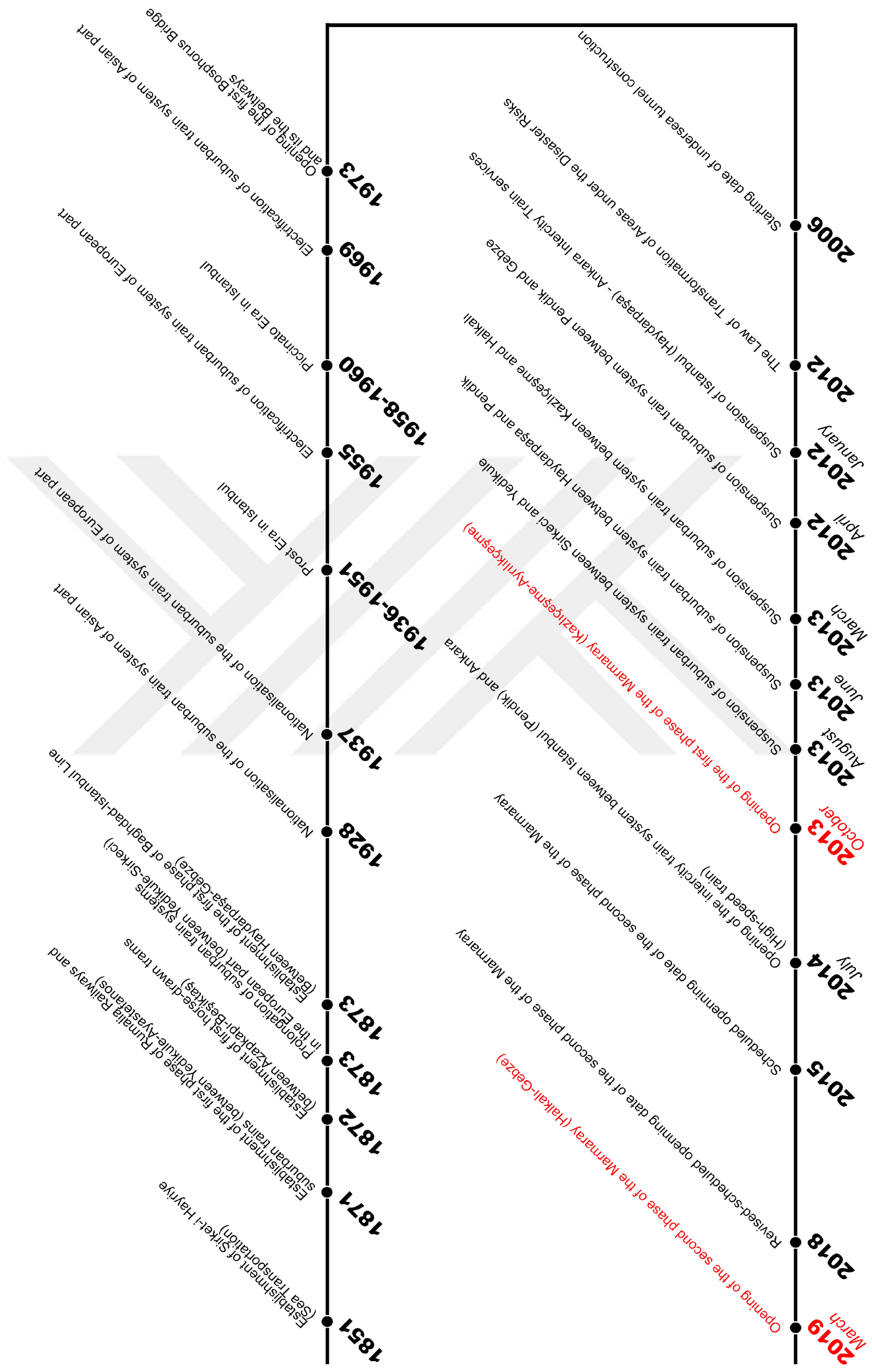

Figure 3.9. Timeline of developments of urban transportation in Istanbul

4. MAPPING THE SPATIAL IMPACTS OF MARMARAY

Istanbul is a city where the mega-infrastructure projects and policies that change the urban landscape are implemented. These changes are observed both in physical and social life. Like the other mega-transportation projects, the Marmaray Railway System alters the landscape of Istanbul. This chapter deals with the impacts of the Marmaray by analysing the distribution of weighted standard land values of specified years and interpreting the visualised maps. The map, given in Figure 4.1, represents the scope area for the analysis.

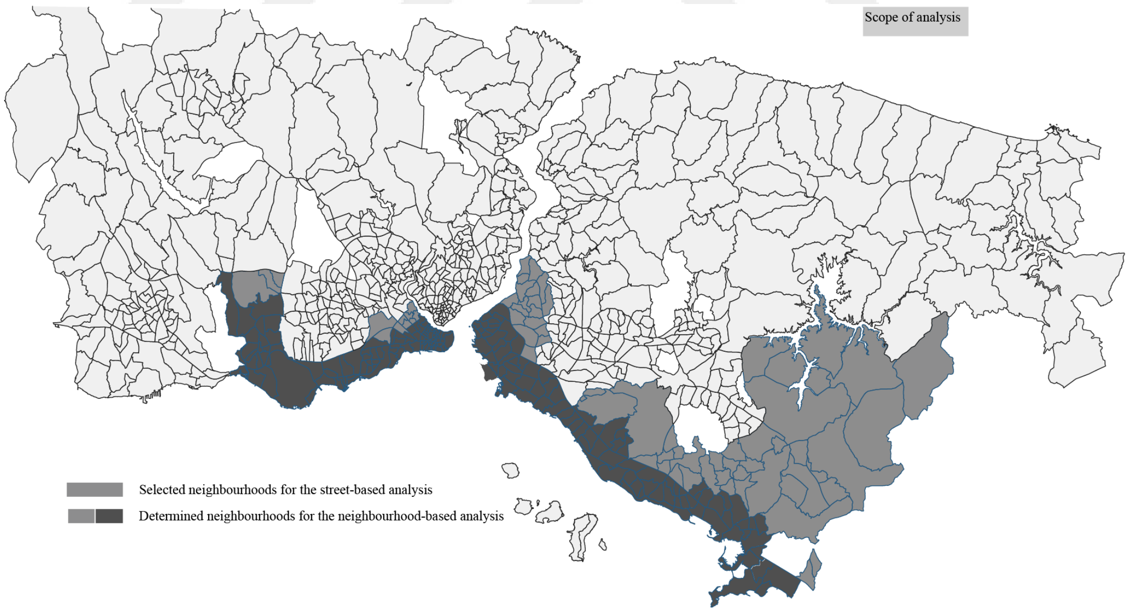

Figure 4.1. Scope areas for the analysis

4.1 General View of Istanbul

Istanbul, to begin with, consists of 39-districts (*Appendix.C: Districts of Istanbul*). In this research, 10-districts where the Marmaray, before it was the suburban lines, passes through, are taken as the case areas. These are, from the West to East, in turn, Küçükçekmece, Bakırköy, Zeytinburnu, Fatih, Üsküdar[24], Kadıköy, Maltepe, Kartal, Pendik and Tuzla. The districts from Küçükçekmece to Fatih are in the European part of Istanbul, and from Üsküdar to Tuzla are in the Asian part of Istanbul. The maps in *Appendix-A* shows the general views of weighted average standard land values of neighbourhoods in mentioned districts. In the left side of the Istanbul Strait, it is represented the suburban train line of the European part which moves between Halkalı (Küçükçekmece) and Sirkeci (Fatih). In the right sight of the strait, it is represented the suburban train line of the Asian side which moves between Haydarpaşa (Kadıköy) and Gebze (a district in the Kocaeli Province). In 2010, both suburban train systems were operated and the connection between the lines was provided by the ferries as a way of transfer mobility. In other words, the waterway is a geographical threshold that separates the suburban train systems. Also, construction works of the Marmaray were already started and continued in 2010 to make a connection between Üsküdar and Fatih through the implementation of an undersea tunnel.

Firstly, the average standard land values of the neighbourhoods are calculated and the population data are matched with relevant neighbourhoods. After analysing the neighbourhood profiles together by Agglomerative Hierarchical Clustering (AHC) in XLSTAT, clusters are generated according to their dissimilarities and similarities on the geographical coordination. As it shows in (Table 4.1), similarities between the classes relatively decrease when the line becomes sharper where is shown on the class-8. It is aimed to keep the dissimilarity less as much as possible within the classes; and high as much as possible between the classes. By this way, profiles of classes become distinct between each other.

[24] There was no suburban train system in Üsküdar. However, when the suburban systems were connected by the Marmaray, one station was established in Üsküdar, opened in 2013.

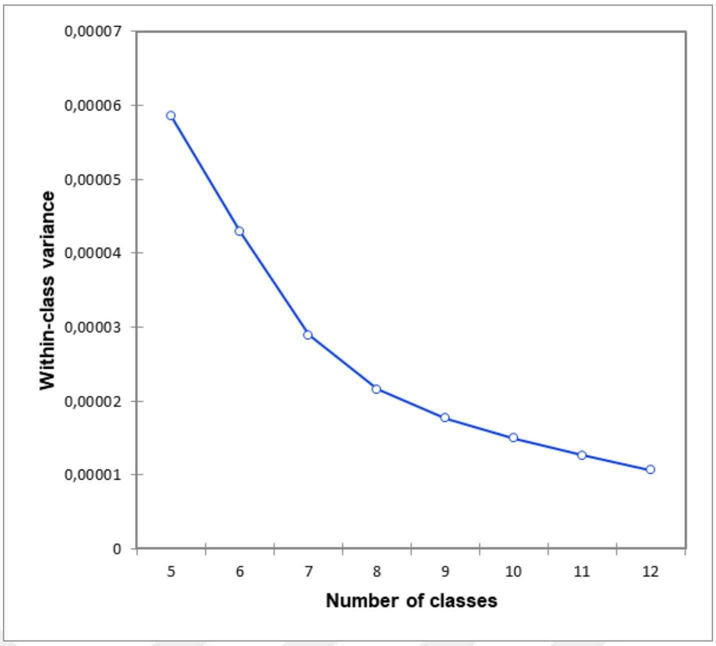

Table 4.1 Similarity percentage within classes of 2018

Three case years show fairly similar curves. On the other hand, the number of classes is taken as 9. Dissimilarity within-class is 3.1% in 2018 and 3.37% in 2014 whereas is 2.12% in 2010 when the number of classes is determined as 8-classes. In this part of the research, it is tried to keep the dissimilarity percentage of less than 3%. Therefore, as it shows in (Table 4.2), it is spesified 9-classes since the percentages of dissimilarity of the case years are less than 3%.

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,000	1,74%	0,003	2,86%	0,000	2,54%
Between-classes	0,001	98,26%	0,117	97,14%	0,001	97,46%
Total	0,001	100,00%	0,121	100,00%	0,001	100,00%

Table 4.2 Percentages of dissimilarities within and between 9-classes of neighbourhoods

Three maps of weighted standard land values of neighbourhoods in 2010, 2014 and 2018 indicate a common ground (*Figure 4.2. Please see Appendix. A for detailed results*). This is the profiles of the urban fringes. On three maps, it shows that urban fringes have the lowest standard land values and thus, are classified in the class of distinctively lowest standard land values. For instance, Tuzla, Pendik, Kartal and relatively Maltepe are categorised in the lowest valued classes in the Asian part whereas Küçükçekmece is classed in the same class as well. However, the core part of the city represents the highest values and are classified representing distinctively highest standard land values. However, minor changes are observed throughout three years and the distribution of classifications is almost stable. This is what the core parts maintain to represent their relatively higher classes and what the edges maintain to represent their relatively lower classes.

Another point is that border between Kadıköy and Maltepe districts acts as a sharp separator in terms of classes on three maps. The sharpest transition from Kadıköy to Maltepe is displayed in 2010 whereas it is observed relatively smoother transition in 2014 and 2018. This can be associated with the lack of suburban train system of the Asian part in 2013 and so transportation difficulties. From Maltepe toward the Eastern districts like Kartal, Pendik and Tuzla, it does not present any sharp and radical changes between the classes in three cases. Like the districts from Maltepe towards to the ones locating in the eastern part, in Üsküdar and Kadıköy, they preserve their class distribution of neighbourhoods and do not represent any sharp turns, although, neighbourhoods in the seashore of Üsküdar are classified in lower valued classes in 2014 and 2018 than 2010.

The changes in the European part point that Fatih, especially the part that meets the Istanbul Strait and Haliç, where has been served as the CBD to the city for years, retains its place in terms of classification and distribution of classes on three maps. Lack of suburban train systems causes a sharp turn on the axes where Fatih meets Zeytinburnu district. It should be kept in mind that there has always been a train system in the core part of Fatih: the suburban train stations in 2010 that connects Fatih to Küçükçekmece and the Marmaray train stations in 2014 and 2018 that connects Fatih to Üsküdar. It represents similar profile changes in Zeytinburnu and Bakırköy. Changes are minor and some neighbourhoods sustain their classes on three maps. Further, Küçükçekmece shares the same profiles with Tuzla, Pendik and Kartal. As an edge district, changes between the neighbourhoods in Küçükçekmece are not observed distinctively as much as the ones locating in the eastern parts on the line. It is examined in detail in the following chapter where the districts are studied separately.

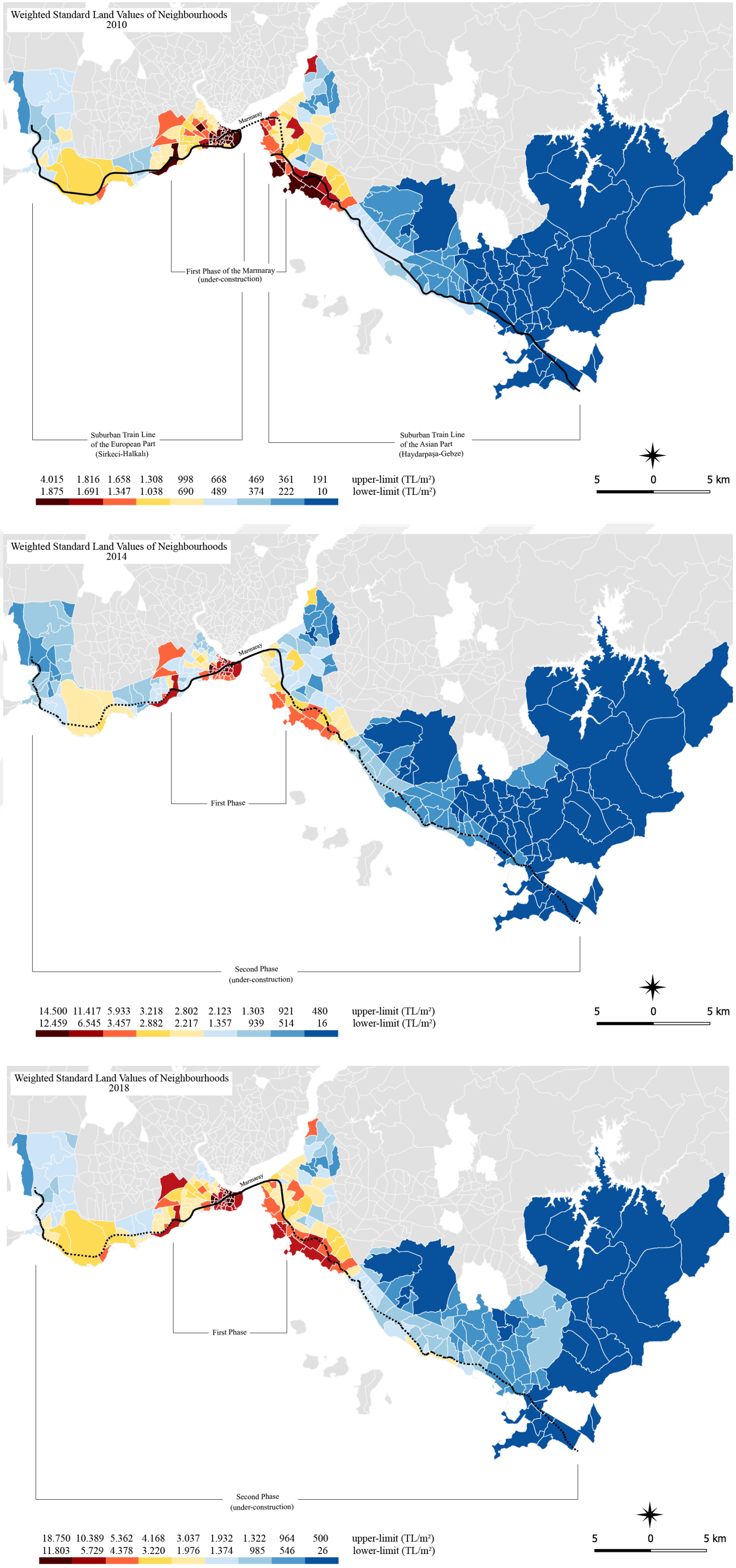

Figure 4.2. Neighbourhood-based general view (2010-2014-2018)

4.2 Küçükçekmece

Küçükçekmece is a district where the departure point of the suburban train system of the European part is located. Likewise, it also maintains this profile by having the Marmaray train stations since the system moves between Halkalı and Gebze. Also, it is surrounded by the Atatürk Airport from the southern border; by the Lake Küçükçekmece along the western shores and boxed up by the Marmara Sea. The southern border is also cut by the D-100 Highway.

According to the general view maps of 2010, 2014 and 2018 (*Figure 4.2*), Küçükçekmece, as a fringe district in the context of specified districts, is classified in the lower valued groups. All maps in Appendix-A represent Küçükçekmece by the blue tones. When all neighbourhoods in Küçükçekmece are analysed, minor changes are observed (*Figure 4.3*). In three-case years, one small neighbourhood (Beşyol) where is contiguous to the Atatürk Airport and D-100 Highway represents invariably the highest standard land values. Average standard land values of neighbourhoods indicate that Cumhuriyet and Yeni Mahalle Neighbourhoods are classified in relatively lower valued groups in 2014 than 2010. Suburban train stations namely Soğukçeşme and Küçükçeşme are located in where are very close to these two neighbourhoods. In 2014 as well as 2018, there is an absence of a suburban train system which may cause some mobility problems. Apart from this, there is not displayed a big jump among the neighbourhoods and their distributions on standard land values.

The second step of the analysis is to observe the changes of classifications of streets for the specified neighbourhoods (Figure 4.4). To determine the areas for the analysis, train stations-centred 2-km radius areas are specified for the street-based analysis. In this context, every neighbourhoods that the circle touches are taken into the analysis. For Küçükçekmece case, 18 neighbourhoods are determined where consists of approximately 1800 streets. The aim is to keep the dissimilarity variance of less than 2% so that further findings can be observed. In the case of analysis based on 9-classes, percentage of dissimilarity within-classes in 2010 becomes 1,17%, whereas 1,54 % in 2014 and 1,49% in 2020 (Table 4.3). Therefore, the distribution of clusters is fitted into 9 categories.

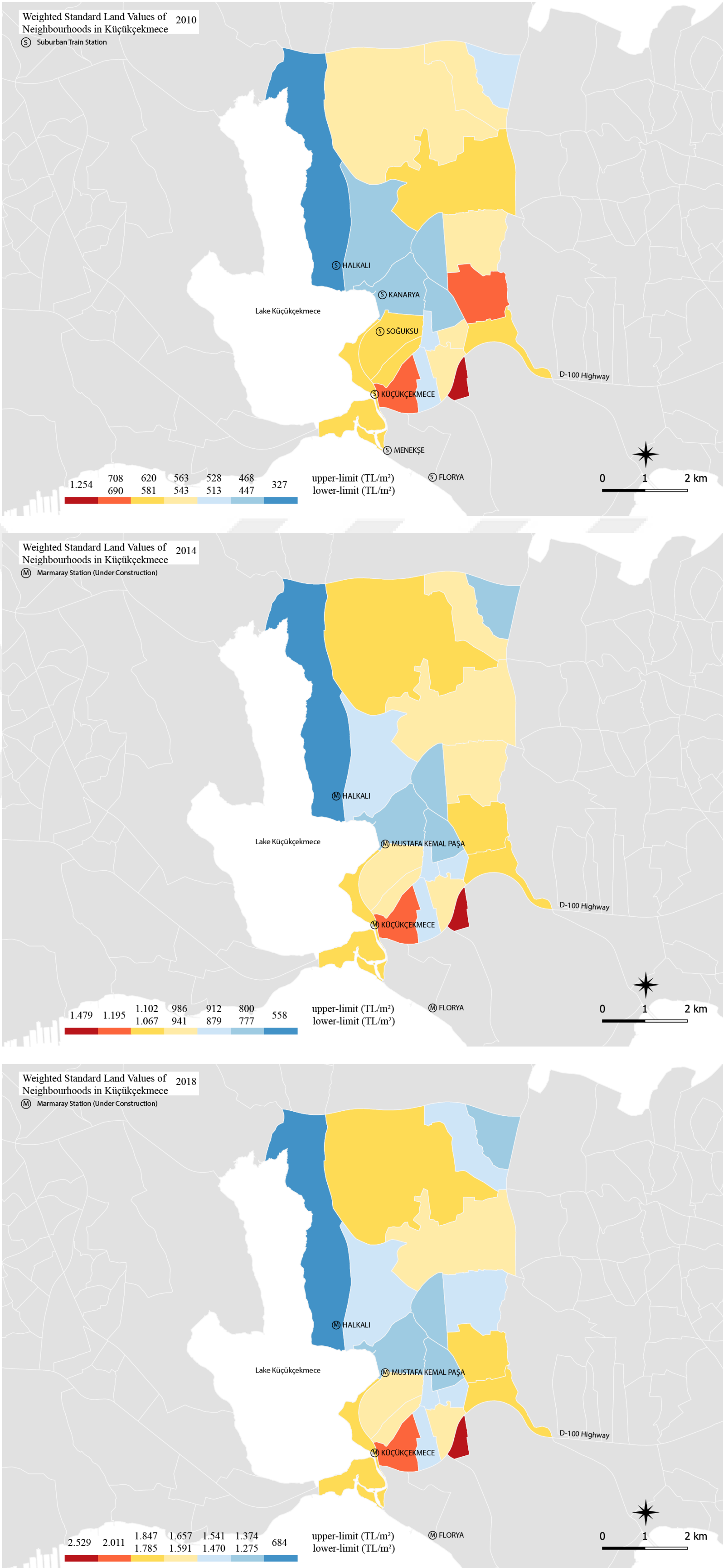

Figure 4.3. Neighbourhood-based maps of Küçükçekmece (2010-2014-2018)

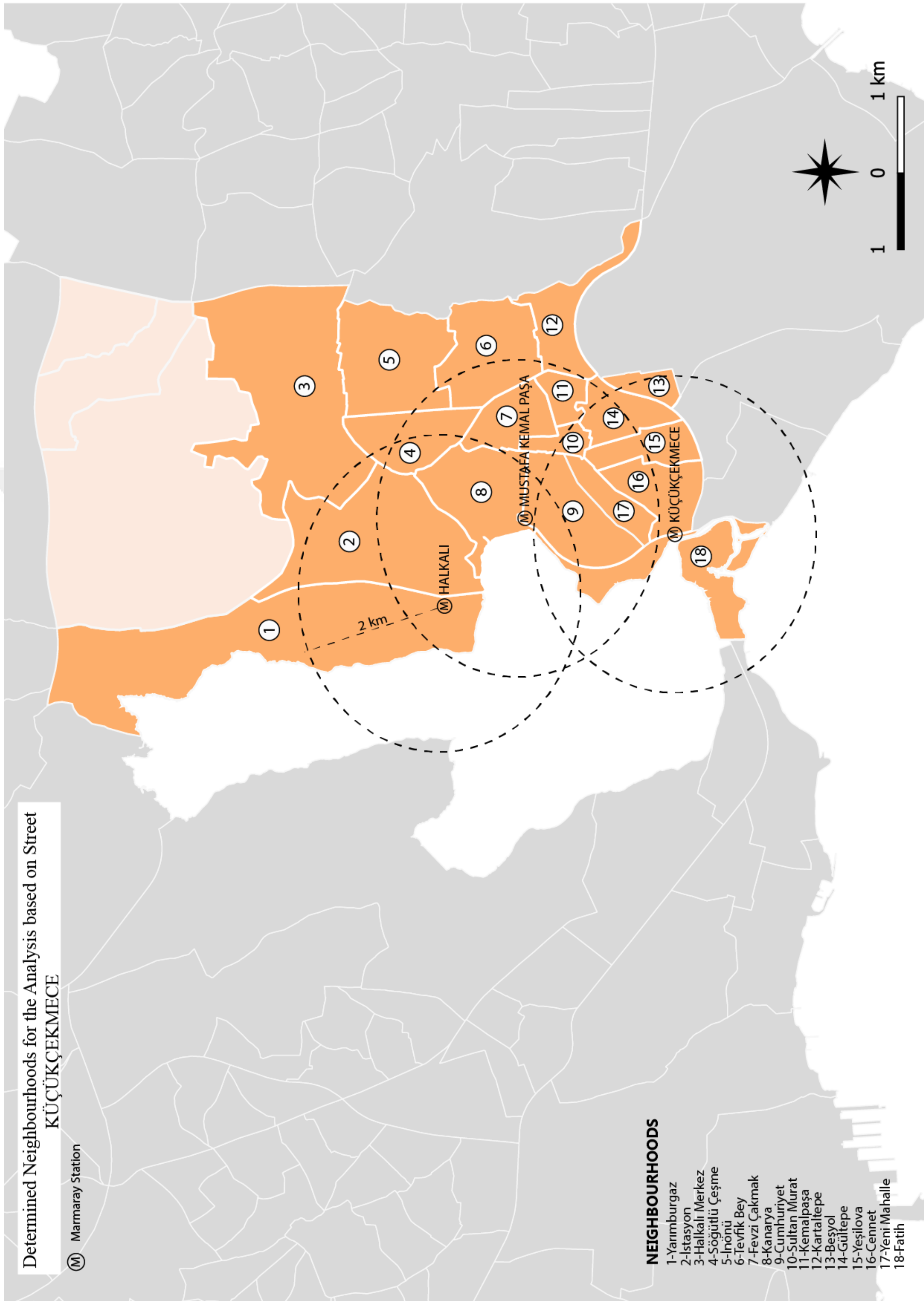

Figure 4.4. Scope area in Küçükçekmece

	2010		2014		2018	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,037	1,77%	0,030	1,54%	0,000	1,49%
Between-classes	2,057	98,23%	1,916	98,46%	0,001	98,51%
Total	2,094	100,00%	1,946	100,00%	0,001	100,00%

Table 4.3 Percentages of dissimilarities within and between 9-classes of standard land values of streets in Küçükçekmece.

Street-based illustrated map of 2010 (*Figure 4.5*) shows that the streets that are clustered within the groups that contain the highest standard land values are aggregated mostly in the south part of Küçükçekmece where the D-100 Highway forms a border. Also, the lowest valued classes exist in clusters in the neighbourhoods such as the steets in Kanarya, Söğütlü Çeşme, and Fevzi Çakmak Neighbourhoods constitute homogenous clusters representing the blue tones. Likewise, Halkalı Merkez and İnönü Neighbourhoods are found in the same way with light blue. As expected, streets having the highest values appear along the D-100 Highway. The highway provides some significant locational opportunities in terms of accessibility. Second-degree aggregated clusters are found in Tevfik Bey Neighbourhood where is located in the southeast part of the district and also found in the southwest part where the Soğuksu and Küçükçekmece suburban train stations exist. This area consists of Cumhuriyet, Fatih and Yeni Mahalle Neighbourhoods. Proximity and accessibility to the train stations and the highway, and also lake view can be counted as the factors that keep the standard land values up.

When the suburban train systems stopped in 2013, some minor changes show up on the map of 2014. Absence of train system leads to a decrease for the areas near the train stations and the colours turn from yellow to blue whereas the streets near the D-100 Highway maintain being in the class that has the highest values among the others. Another significant point that map-2014 (Figure 4.5) shows that the streets on the main axes are clustered within distinctively higher classes. Apart from these areas, the rest of the district maintain its distribution in terms of classes. Further, the map of 2018 (Figure 4.5) displays almost the same distribution of classes like the ones in 2014.

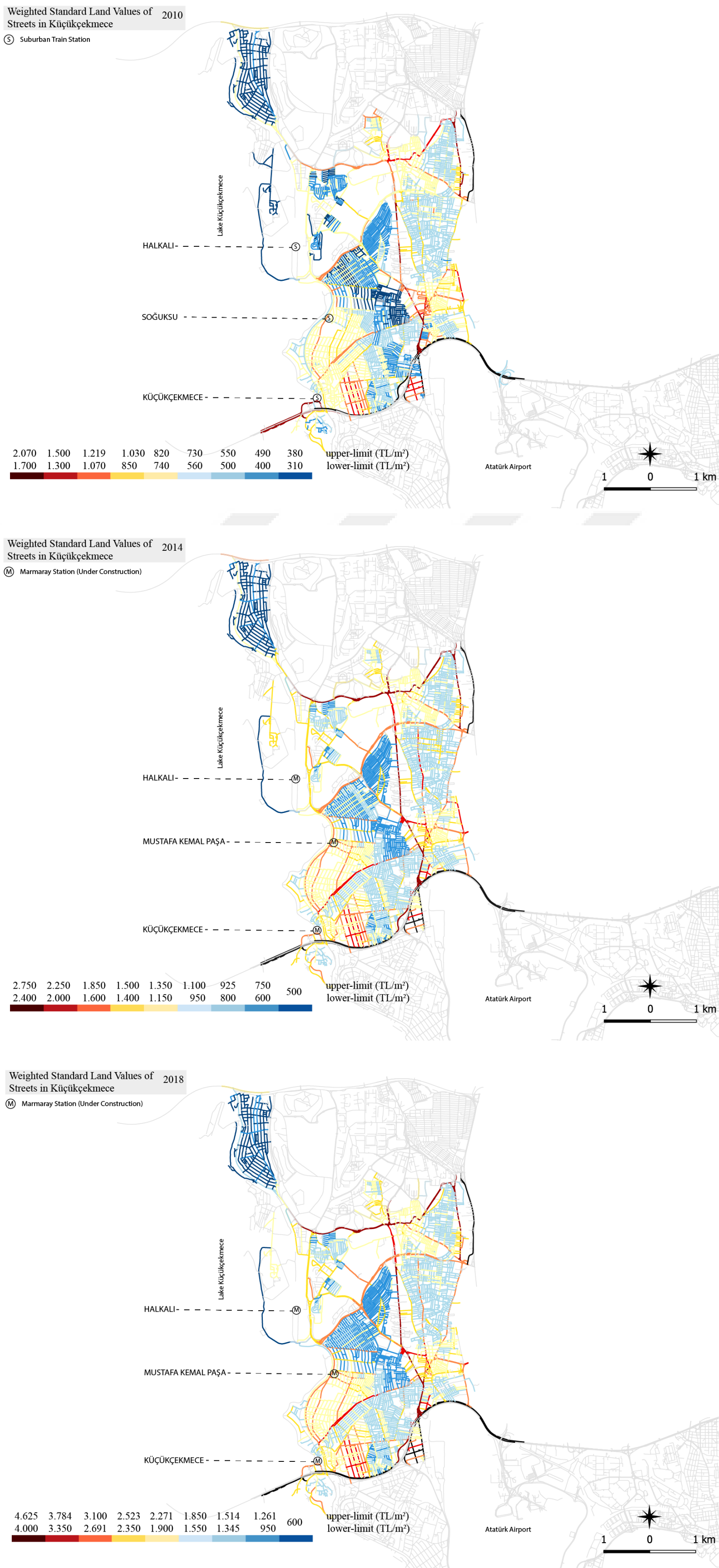

Figure 4.5. Street-based maps of Küçükçekmece (2010-2014-2018)

In brief, although, the existence of train stations impacts the area where they are located and keep the standard land values upper in comparison with the rest of the district, however, absence of the train systems due to the construction of the new one causes a change in the distribution of classes. Therefore, the areas where are close to the stations are clustered within lower classes. Except for the main routes, the rest of the district does not monitor major changes in terms of the classification.

4.3 Bakırköy

Bakırköy is a district where lies between Küçükçekmece and Zeytinburnu districts. It is surrounded by the D-100 Highway from the north part and the Marmara Sea from the south part. Istanbul Atatürk Airport occupies a considerable amount of place in Bakırköy. As it is mentioned in Section.3, suburban train line has encouraged the urban development in Bakırköy where it has always served as a peripheral district.

According to the general view maps of 2010, 2014 and 2018 (*Figure 4.2*), the groupings of neighbourhoods in Bakırköy always represent in the middle and upper-middle-valued classes among the other neighbourhoods in Istanbul. The distinction between the middle and upper-middle classes is viewed also on the neighbourhood-based maps (*Figure 4.6*). By comparison with the neighbourhoods in itself, east wing of the district indicates distinctively lower groups of neighbourhood-based average standard land values whereas the left-wing of the district indicates distinctively higher-valued groups.

5-classes are chosen since the percentage of dissimilarities within classes are less than 2%. Table 4.4 shows that dissimilarity percentage within-classes and between classes, in turn, is 1,72% and 98,28% in 2010; 0,98% and %99,02% in 2014; and 2,16% and 97,84% in 2018. Analysis results meet the expectations.

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,002	1,72%	0,001	0,98%	0,002	2,16%
Between-classes	0,097	98,28%	0,065	99,02%	0,074	97,84%
Total	0,098	100,00%	0,066	100,00%	0,076	100,00%

Table 4.4 Percentages of dissimilarities within and between 5-classes of neighbourhoods in Bakırköy.

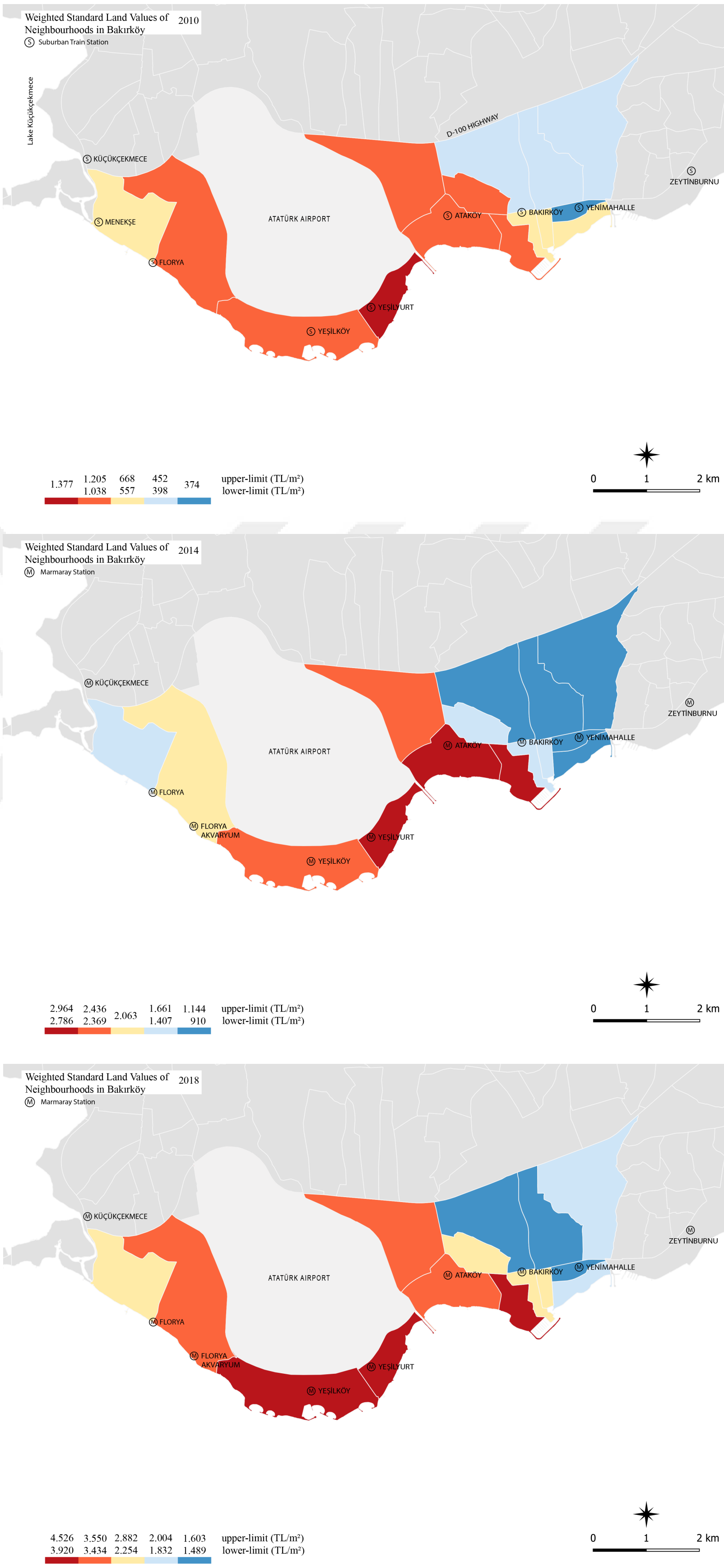

Figure 4.6. Neighbourhood-based maps of Bakırköy (2010-2014-2018)

The map of average standard land values of the neighbourhoods of 2010 (*Figure 4.6*) in Bakırköy displays that the highest and upper-middle-valued groups are located where they are adjacent to the airport area. To compare the neighbourhood maps of 2010 (*Figure 4.6*) and 2014 (*Figure 4.6*), it depicts that although Basınköy and Şenlikköy Neighbourhoods are grouped, in turn, in middle and upper-middle-valued classes in 2010, however, they are grouped in relatively lower-valued classes in 2014. Except for Yeşilköy, Yeşilyurt and Yenimahalle Neighbourhoods, all the areas are also grouped in lower-valued classes. A marked difference is observed in Ataköy 3-4-11.Kısım Neighbourhood. It is grouped in the upper-middle valued class in 2010, however, it is later grouped in lower-middle-valued lass in 2014.

To compare the neighbourhood maps of 2014 and 2018 (*Figure 4.6*), the changes show that majority of neighbourhoods are grouped in an upper-valued class in 2018. The ones that are stable from 2010 to 2018 in terms of groupings are Yeşilyurt where is represented the highest average land values; and Yenimahalle where is represented the lowest average land values.

It is enabled to observe the changes in detail through the street-based maps of weighted standard land values in Bakırköy. To spesify the areas for the analysis, train stations-centred 2-km radius areas are specified for the street-based analysis. In this context, all neighbourhoods in Bakırköy are taken into the analysis (Figure 4.7).

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,007	0,69%	0,000	1,01%	0,000	1,12%
Between-classes	1,009	99,31%	0,002	98,99%	0,002	98,88%
Total	1,016	100,00%	0,002	100,00%	0,002	100,00%

Table 4.5 Percentages of dissimilarities within and between 9-classes of standard land values of streets in Bakırköy.

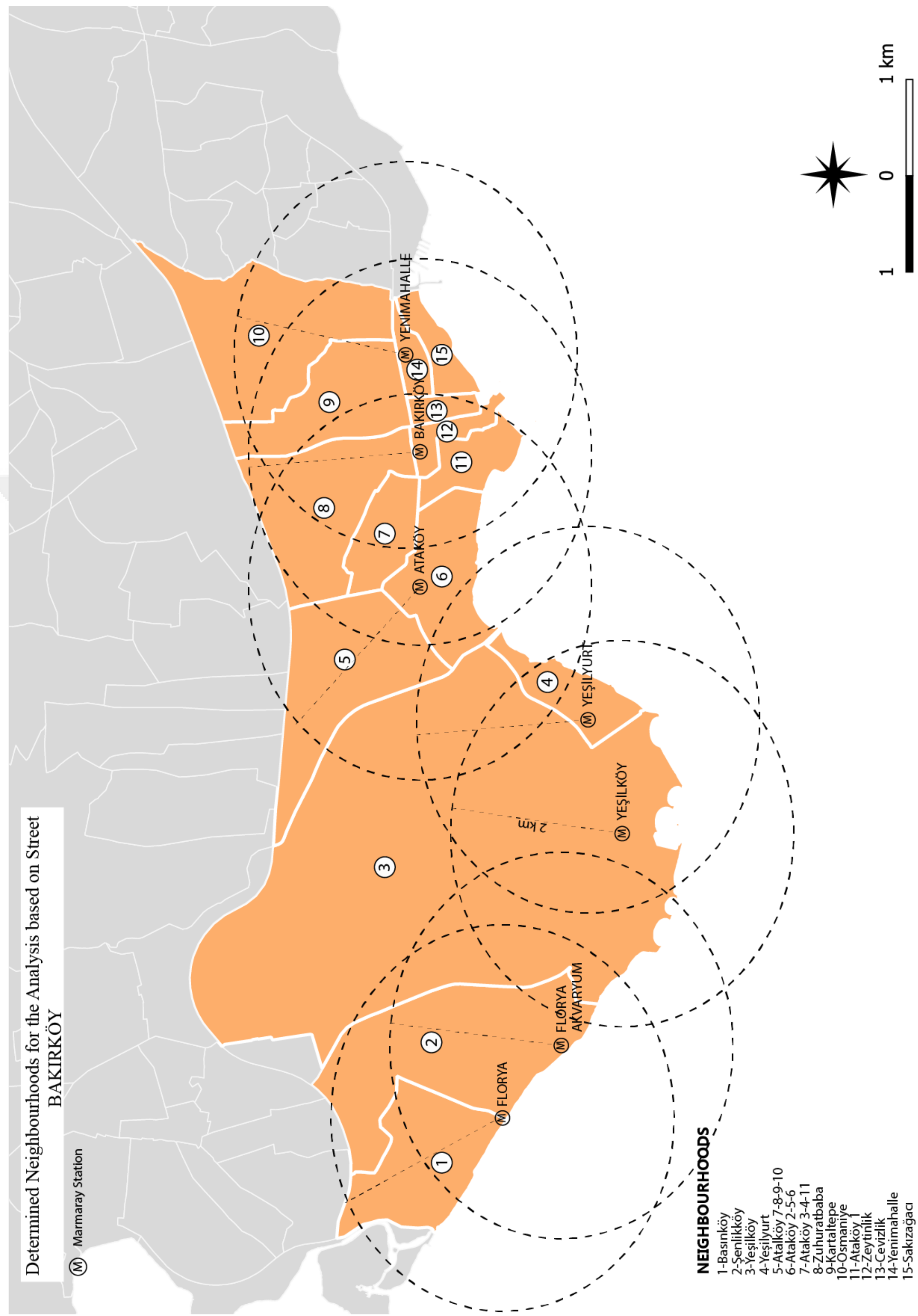

Figure 4.7. Scope area in Bakırköy

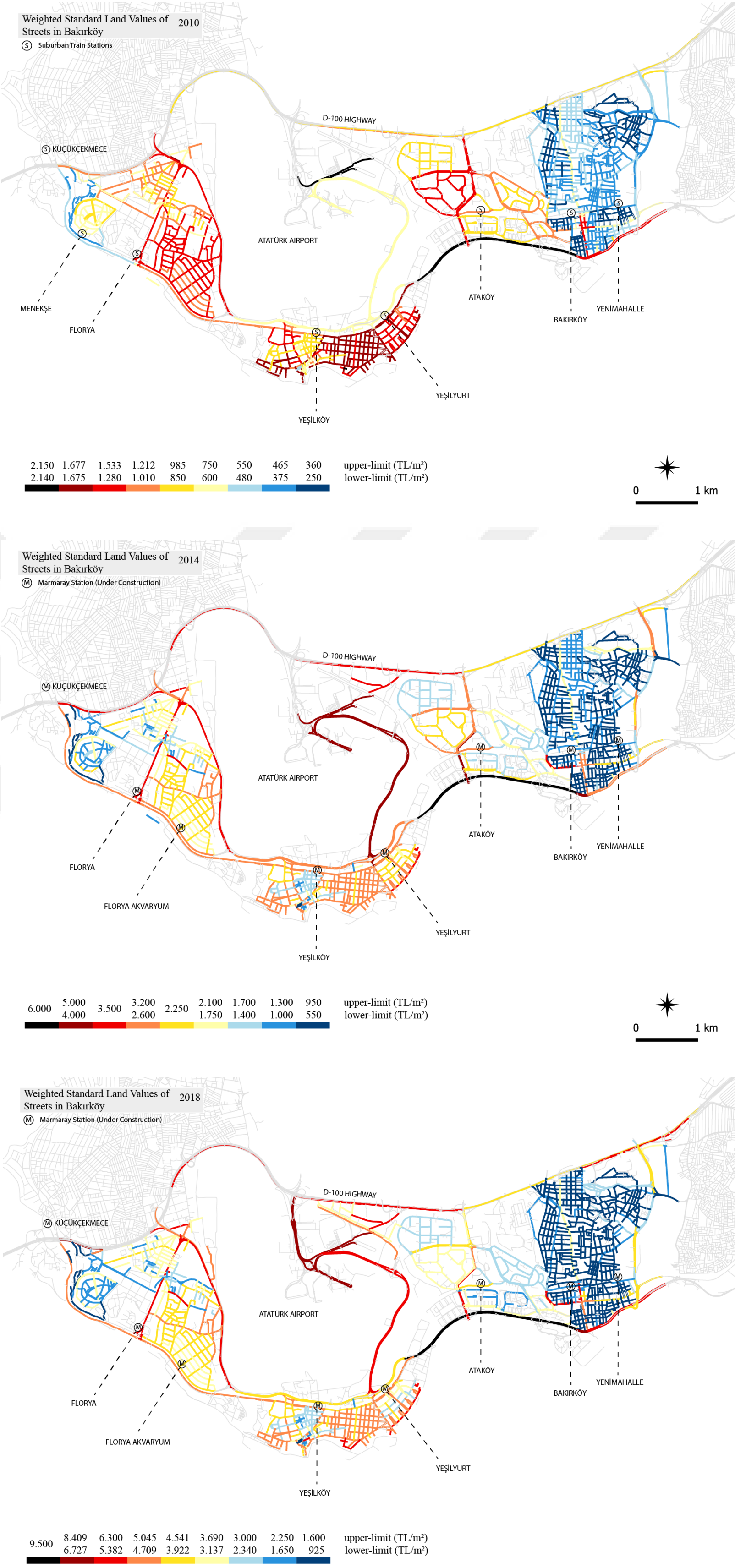

Figure 4.8. Street-based maps of Bakırköy (2010-2014-2018)

Street-based map of weighted standard land values of 2010 (*Figure 4.8*) shows that the streets that are grouped in the highest-valued clusters are located around the airport area as it is also observed in the neighbourhood-based maps of Bakırköy as well as the lowest-valued clusters are presented over the east wing of the district. Besides, the areas where the suburban train stations are located, represent relatively higher values in comparison with the station-centred broader areas.

To compare with the map of 2014 (*Figure 4.8*), noticeably changes in terms of street values are observed. Even if increase rate of standard land values from 2010 to 2014 is considerably higher than the increase rate from 2014 to 2018 (*Figure 4.8*), however, distribution of groups does not represent the same increase rate. In this context, the areas that are represented the highest values on the map of 2010, are represented generally lower-middle, middle and upper-middle-valued classes in 2014. In other words, many of them are clustered in 2 or 3-lower groups where the train stations are located. Some areas, where the Bakırköy and Yenimahalle train stations are found, are also grouped in 1-lower class in 2014.

When the maps of 2014 and 2018 are compared, minor changes are monitored. Year-2018 is when there is still no train connection in Bakırköy. In this case, areas in the east wing of the district, the upper side of the Bakırköy and Yenimahalle train stations, are grouped in the lowest classes as well as the area where is the upper part of Ataköy train station, is grouped 1-lower class. In brief, the absence of the suburban train system is more effective for the distribution of groups in terms of standard land values. Therefore, major changes show up in the comparison with 2010 and 2014 whereas the minor changes appear in the comparison with 2014 and 2018.

4.4 Zeytinburnu

Zeytinburnu district is in the middle of Bakırköy and Fatih districts where is established just next to the historic city walls as the border to Fatih. Besides, it has been served as an "industrial zone" to the city. As it shows on the general view maps (*Appendix A*), the majority of neighbourhoods in Zeytinburnu represents the highest and upper-middle-valued classes in Istanbul.

Percentages of dissimilarities within-classes less than 2% are obtained by specifying 7-classes for the neighbourhood-based analysis. As it shows in Table 4.6, only the dissimilarity within-classes are less than 1% in 2014 whereas 2010 and 2018 are 1,06% and 1,50% which are expected results.

	2010		2014		2018	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,000	1,06%	0,002	0,72%	0,000	1,50%
Between-classes	0,021	98,94%	0,232	99,28%	0,020	98,50%
Total	0,021	100,00%	0,234	100,00%	0,020	100,00%

Table 4.6 Percentages of dissimilarities within and between 7-classes of neighbourhoods in Zeytinburnu.

There is no considerable difference between the maps of weighted average standard land values of neighbourhoods (*Figure 4.9*). It should be kept in mind that the suburban train system has been stopped in March-2013 and the first phase of the Marmaray has opened in October-2013. It is clear that, Kazlıçeşme train station has always been operated except for no train system for 7-months due to the construction works of the Marmaray. Kazlıçeşme neighbourhood is included in the class that has the highest values as it shows on the neighbourhood-based maps. Also, the neighbourhoods that are separated by the D-100 Highway are grouped in high-valued class with orange-colour. Apart from these neighbourhoods, majority of them consists of lower-middle valued classes.

It is enabled to observe the changes in detail through the street-based maps of weighted standard land values in Zeytinburnu. To specify the areas for the analysis, train stations-centred 2-km radius areas are specified for the street-based analysis. In this context, except 2 neighbourhoods in the north part of the district, all neighbourhoods in Zeytinburnu are taken into the analysis (Figure 4.10).

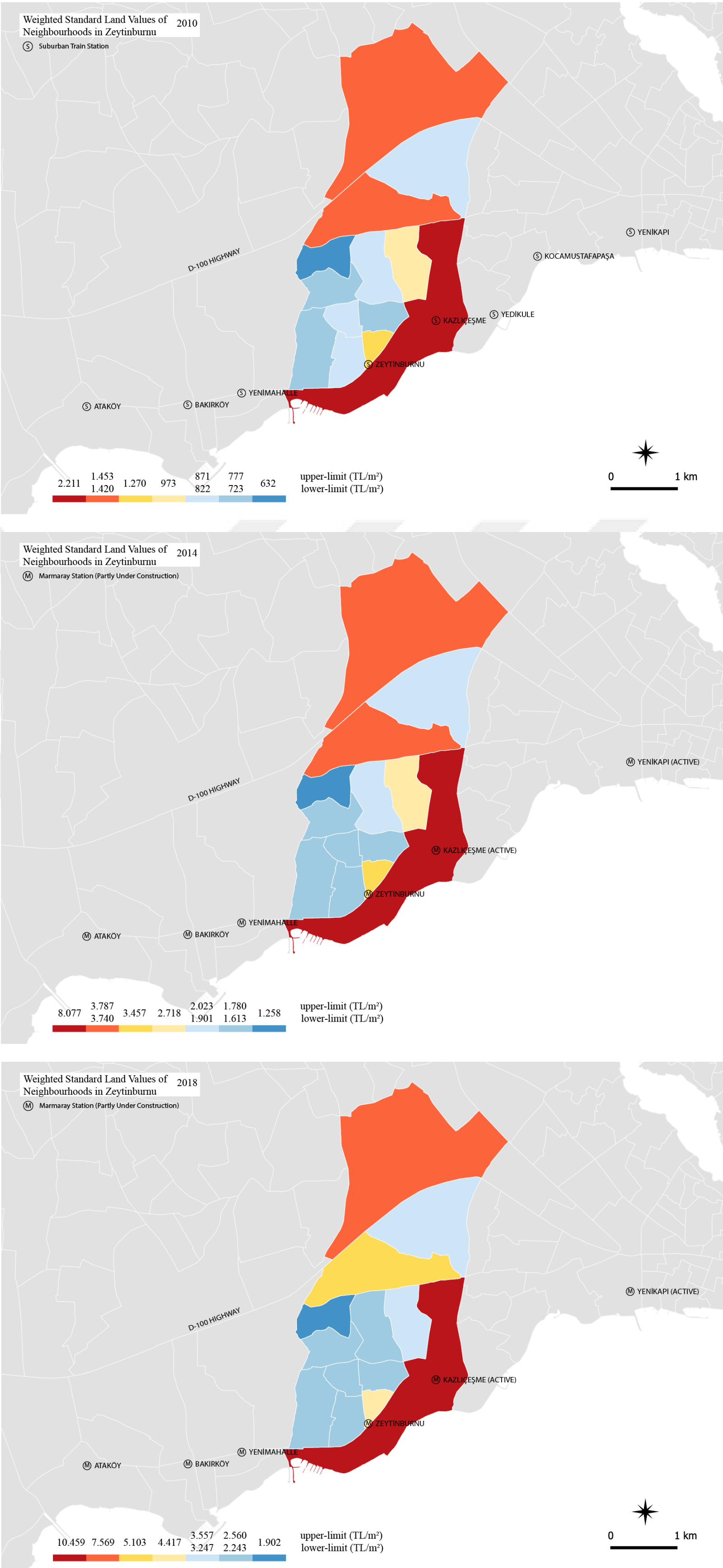

Figure 4.9. Neighbourhood-based maps of Zeytinburnu (2010-2014-2018)

As the other street-based analyses, based on 9-classes analysis are adopted. In this context, percentages of dissimilarities within-classes is in turn 0,38% in 2010; 0,72% in 2014; and 0,59% in 2018 (Table 4.7). Percentages of dissimilarities are quite lower than expectations. This means that dissimilarities between classes are distinguished and similarities within classes are as much as resemble.

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,000	0,38%	0,000	0,72%	0,000	0,59%
Between-classes	0,002	99,62%	0,002	99,28%	0,001	99,41%
Total	0,002	100,00%	0,002	100,00%	0,001	100,00%

Table 4.7 Percentages of dissimilarities within and between 9-classes of standard land values of streets in Zeytinburnu.

Street-based maps (*Figure 4.11*) demonstrate that the distribution of street-based standard land values is distinctly visible. The distribution consists of the separation of highest and lowest values. To clarify the matter, highest-valued classes are assigned to the main streets and the main axes whereas the lowest-valued classes are observed in the areas where the streets which are not the main axes come together and create the settlements in the neighbourhoods. The changes are seen generally in the main axes on the street-based maps. In this context, a comparison between 2010 (*Figure 4.11*) and 2014 (*Figure 4.11*) reveals that the areas around the Kazlıçeşme train station raise its value and grouped in higher-valued classes where the other main axes loss their values and the classification of the streets that form the settlements remain unchanged. As it mentions above, Kazlıçeşme train station has always been under service. 2013 is when the suburban train system has been stopped while the Marmaray has been started the operation in also 2013. What is significant between analysed two years is that standard land values are doubled or even more. Accelerated urban renewal process that was sparked in 2012 may be the dominant factor for such a big change.

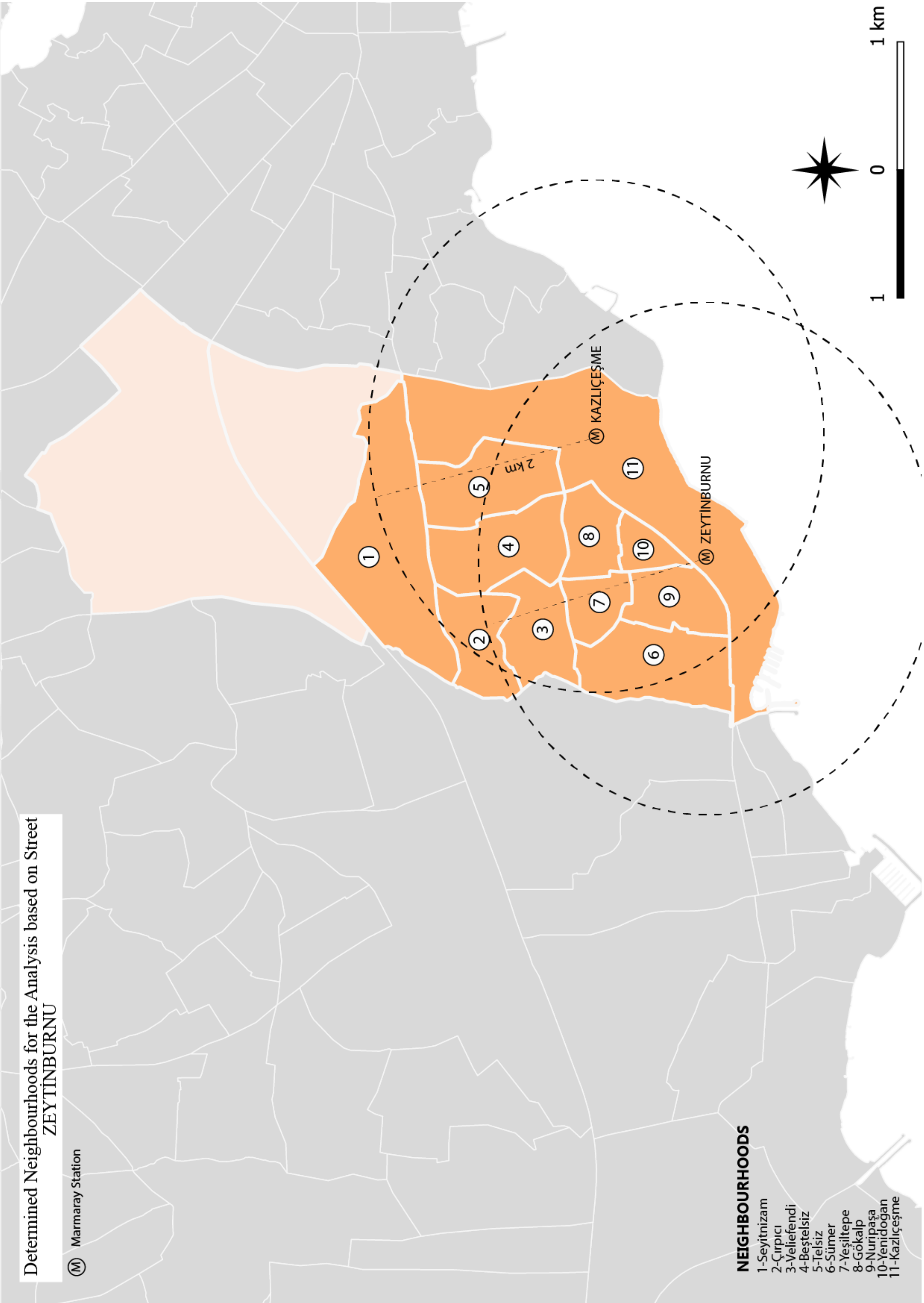

Figure 4.10. Scope area in Zeytinburnu

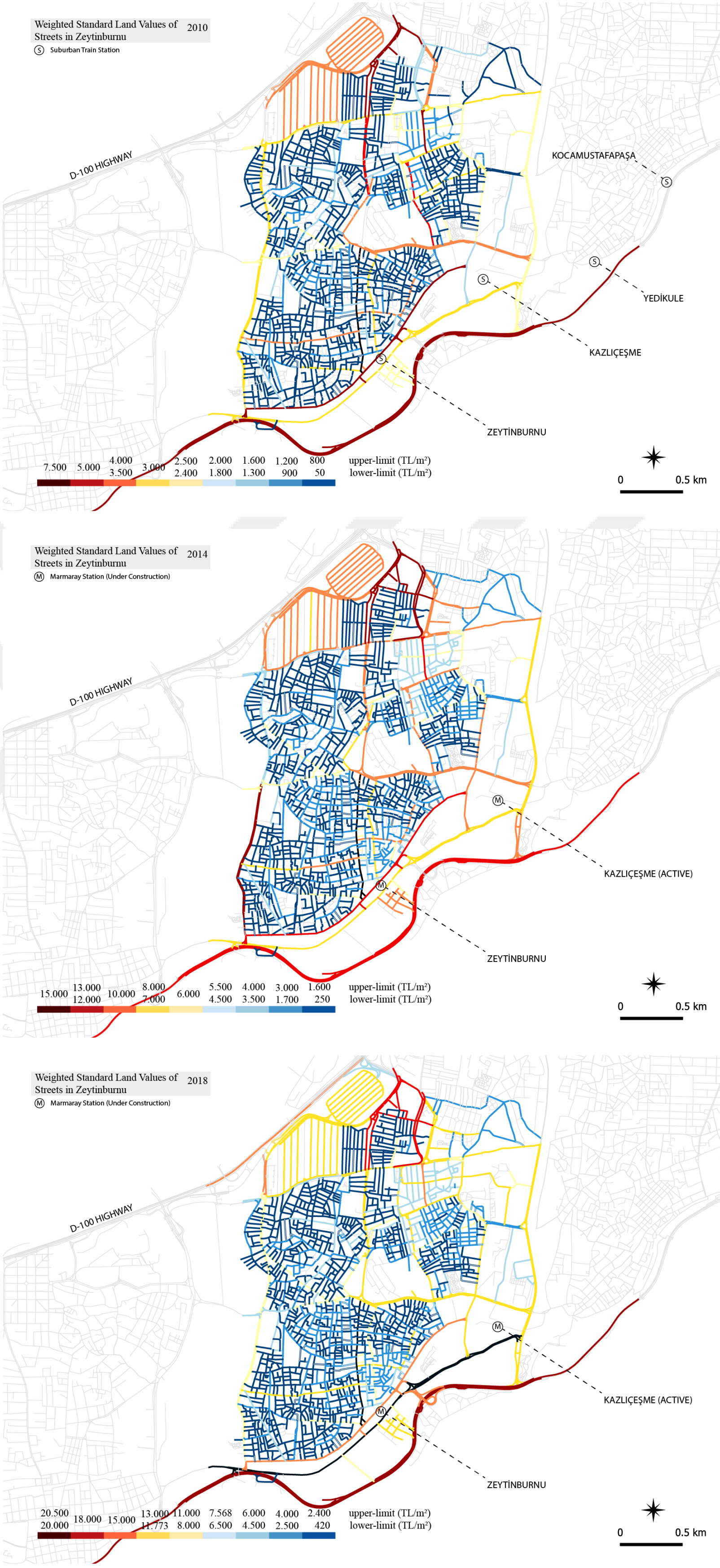

Figure 4.11. Street-based maps of Zeytinburnu (2010-2014-2018)

Street-based map of 2018 (*Figure 4.11*) displays that on the one hand, the street (Demirhane Caddesi) that is located under the Kazlıçeşme train station is grouped in the highest-valued class representing black colour. On the other hand, this street does not represent the same colour on the 2010 and 2014 maps. Besides, the street that is along the seashore is still grouped in one of the highest-valued class as well as classification in 2010 and 2014. Apart from these points, almost all the main axes and main streets are grouped in lower-valued classes in 2018 in comparison with 2010 and 2014 while the other streets around the settlements show a resistance to change in terms of classification. In brief, observable changes are held only in the main streets and main axes in Zeytinburnu. Also, the streets where are found around the Kazlıçeşme train station, that has been always under operation, are always grouped in relatively higher-valued classes in comparison with the others.

4.5 Fatih

Fatih, where is established on the historical peninsula, has been the administrative centre of the empires for centuries until the new capital has been moved to Ankara. Being the administrative centre has made the land values in the district the most expensive ones in comparison with the other districts. Also, Fatih has contained the functions that made it the CBD of the city until the new CBDs areas such as Mecidiyeköy and Büyükdere Axis has been opened. Nevertheless, the neighbourhoods, where are located in where the Marmara Sea, Istanbul Strait and Estuary (Haliç) come together, retain their relatively higher land values. So, a large part of the Fatih district is represented with the darkest colours on the general view maps of 2010, 2014 and 2018 (*Appendix A.*).

It should be kept in mind that, as is the case with Zeytinburnu, there has always been a train system in Fatih. Suburban train system between Sirkeci and Yedikule was stopped operation in 2013-August whereas the first phase of the Marmaray train system was put in operation in 2013-October.

Percentages of dissimilarities within classes are aimed to keep under 2% as in the previous cases. Therefore, 9-classes based classification is specified for the neighbourhood-based analysis (Table 4.8). Thus, dissimilarity percentage of 2010 is 1.53%; of 2014 is 1,82%;

and of 2018 is 1,59% within classes. Similarity percentages are, in turn, 98,47%, 98,18%, and 98,41% between classes.

	2010		2014		2018	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,000	1,53%	0,000	1,82%	0,001	1,59%
Between-classes	0,002	98,47%	0,001	98,18%	0,080	98,41%
Total	0,002	100,00%	0,001	100,00%	0,082	100,00%

Table 4.8 Percentages of dissimilarities within and between 9-classes of neighbourhoods in Fatih.

Neighbourhood-based maps show that there are no major differences in between analysed periods. According to the neighbourhood-based maps (*Figure 4.12*), distribution of land values is strict. An axis from Yenikapı train station toward the Estuary-Haliç constitutes a distinct separation between low and high average standard land values. In this context, left side of the axis is coloured with the tones of blue in 2014 (*Figure 4.12*) and 2018 (*Figure 4.12*) while it is coloured with the tones of yellow in 2010 (*Figure 4.12*). The right side of the axis represents the highest average land values where is also the core part of Fatih in terms of the CBD. The core part sustains representing the highest average land values. On the one hand, major changes are not observed on the neighbourhood-based maps, on the other hand, average land values of the neighbourhoods are doubled and even tripled in some classes from 2010 to 2014. Rate of increase from 2014 to 2018 is less than 2010 to 2014.

It is enabled to observe the changes in detail through the street-based maps of weighted standard land values in Fatih. To determine the areas for the analysis, train stations-centred 2-km radius areas are specified for the street-based analysis. In this context, 50-neighbourhoods in Fatih are taken into the analysis (Figure 4.13).

	2010		2014		2018	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,000	0,65%	0,014	1,01%	0,000	1,10%
Between-classes	0,001	99,35%	1,395	98,99%	0,001	98,90%
Total	0,001	100,00%	1,409	100,00%	0,001	100,00%

Table 4.9 Percentages of dissimilarities within and between 9-classes of standard land values of streets in Fatih.

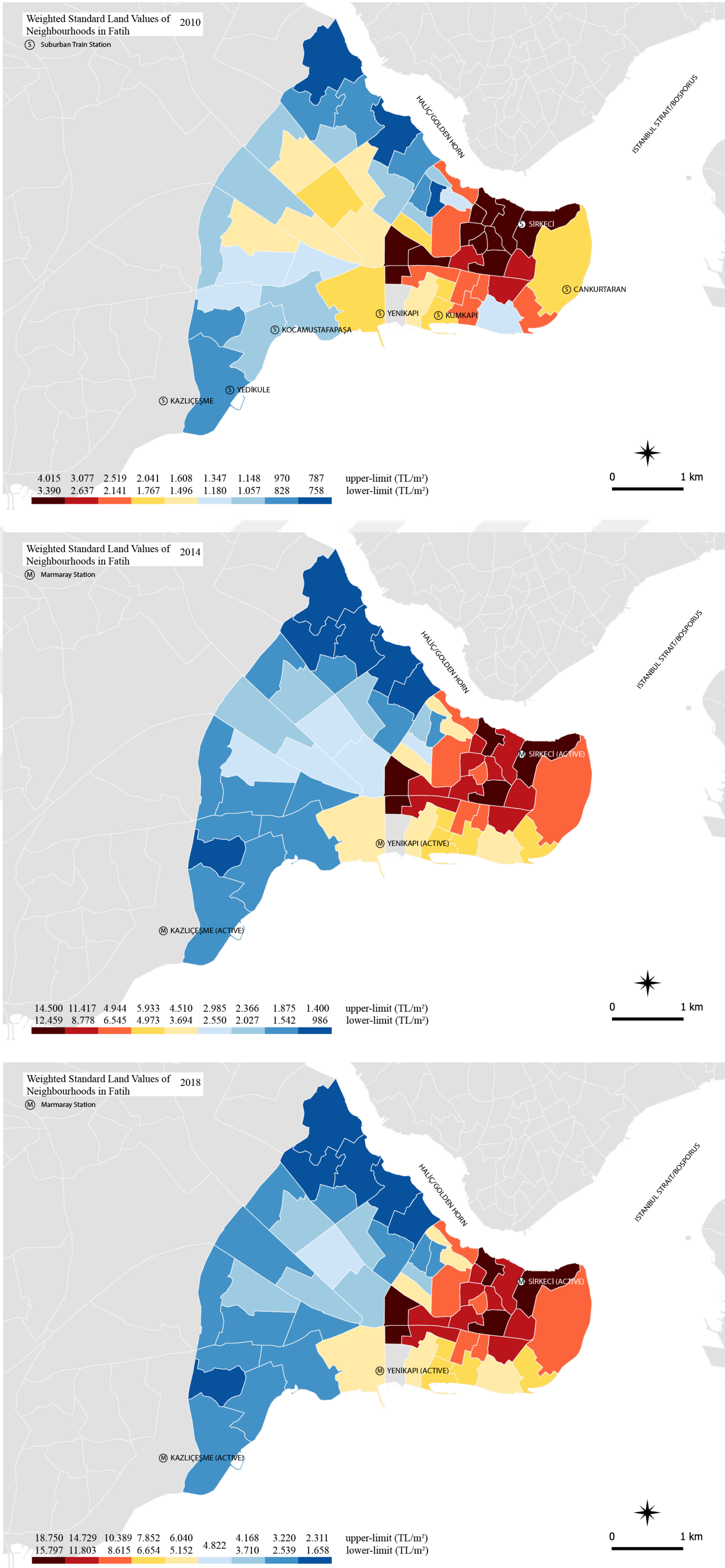

Figure 4.12. Neighbourhood-based maps of Fatih (2010-2014-2018)

To keep the percentages of dissimilarities under 2%, the analysis is done based on 9 classes (Table 4.9). Dissimilarity percentages within classes are 0,65% in 2010; 1.01% in 2014; and 1,10% in 2018 whereas the similarity percentages are 99,35% in 2010; 98,99% in 2014; and 98,90% in 2018. Results meet the expectations of the analysis.

Street-based analyses monitor quite a little of changes on three maps (*Figure 4.14*). Clusters can be observed over the district. For instance, the streets in the core part represent the distinctively very high and the highest colours around the Sirkeci train station. Also, the main axes represent the highest-valued classes. The area around the Yenikapı train station enables the changes to be visible. In the case of the street-based map of 2010 (*Figure 4.14*), a large part of the streets that create this area is grouped in the middle-valued classes representing with light and dark yellow colours whereas the main axes that pass through this area are grouped in the higher-valued classes representing with the light red and the streets that surround this area is grouped in distinctively lower-valued classes representing with the light and dark blue. However, the map of 2014 (*Figure 4.14*) demonstrates that the weight of this area is pushed up the higher classes and the representation is done with the orange and red colours. Yenikapı has a distinctive feature than the others. It is where Marmaray system is put in service and Yenikapı train station is established as a transfer centre where the Marmaray Train System, Yenikapı-Atatürk Airport Metro Line (M1A), Yenikapı-Kirazlı Metro Line (M1B), and Yenikapı-Hacıosman Metro Line (M2) come together. Therefore, it is expected that the weight of the streets is pushed up more than 2-classes. In addition to Yenikapı area, the streets around Sirkeci train station are also grouped in relatively higher classes in 2014. Map of 2018 (*Figure 4.14*) does not display major changes. Instead, weighted land values are sustained and the streets around Yenikapı and Sirkeci train stations still represent the distinctively higher and the highest classes. Lastly, according to the maps, construction of the Eurasia Tunnel that connects the Asian part to the European part through an undersea tunnel and opened in 2016, unexpectedly does not impact the weight of streets along the southern shores in Fatih. It should be kept in mind that Fatih is a saturated district in terms of property values. Minor changes in distribution of values are predicted.

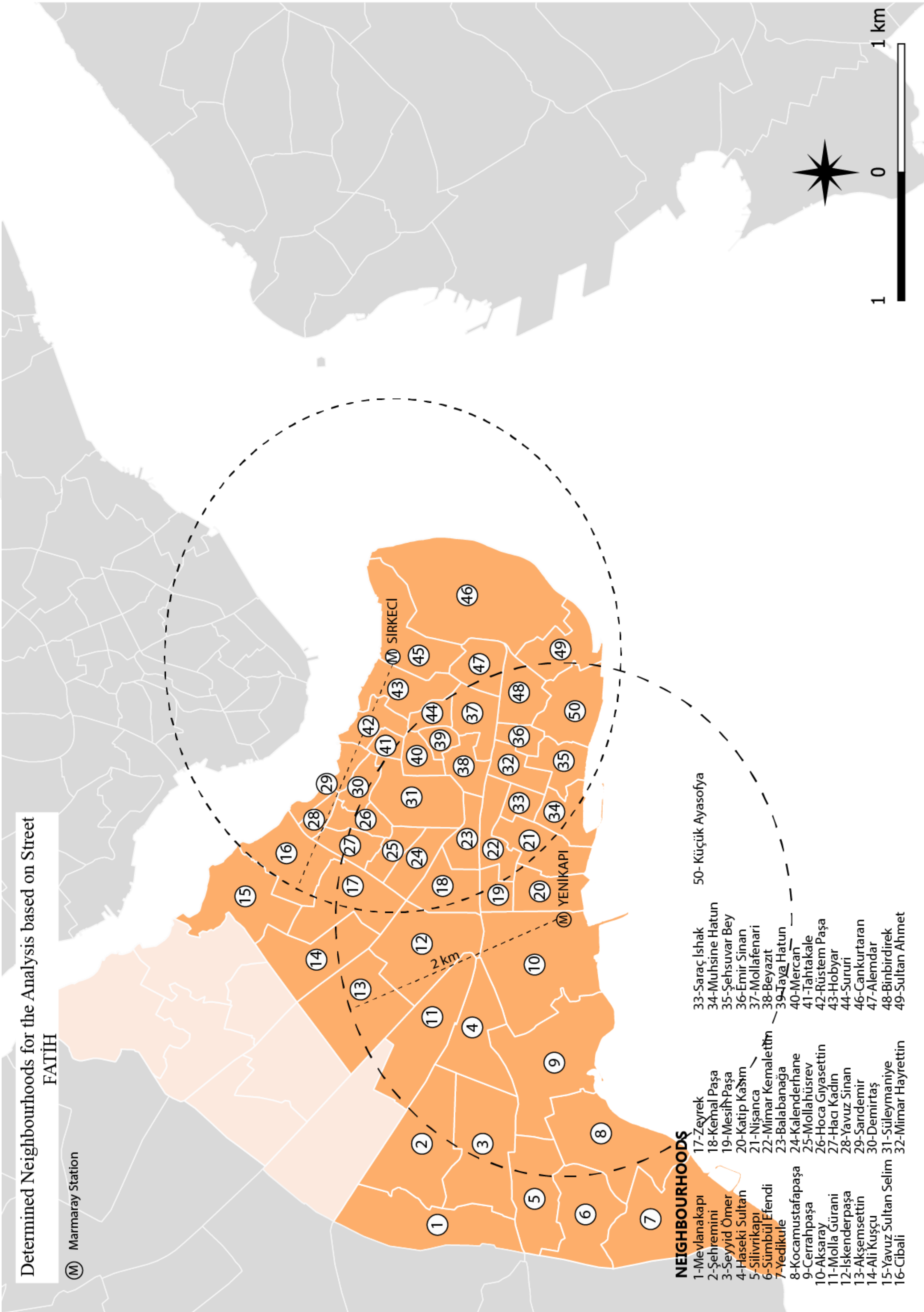

Figure 4.13. Scope area in Fatih

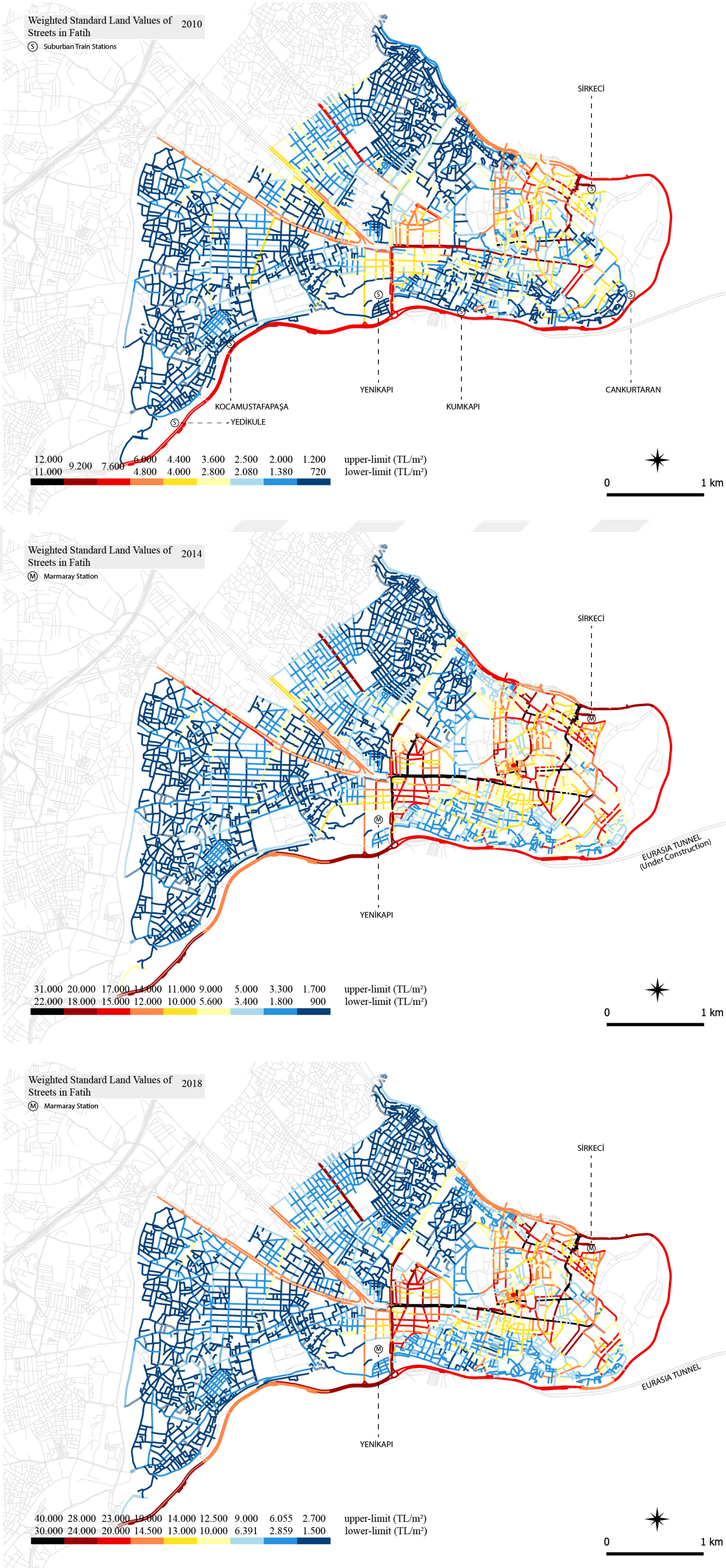

Figure 4.14 Street-based maps of Fatih (2010-2014-2018)

4.6 Üsküdar

Üsküdar, as it mentions in Section.3, contains one of the earliest settlements in Istanbul. Its border lies along the Istanbul Strait and touches upon the Marmara Sea. Although, there have been some horse-driven tram lines throughout history, however, major types of current transportation systems are sea transportation and motor vehicles such as public busses and shared-vehicles. The first Bosporus Bridge that connects Beylerbeyi Neighbourhood towards Ortaköy/Beşiktaş and its access way which is an extension of the D-100 Highway split the district. Since the suburban train systems has ended in Haydarpaşa/Kadıköy, there was no any suburban line in Üsküdar until the Marmaray system has been opened. Üsküdar is a gateway to make a connection between the European and Asian sides through the Marmaray. For this purpose, a Marmaray train station, namely Üsküdar, has been located in where the Marmara Sea meets Istanbul Strait and opened in 2013 as the first phase of the project.

Neighbourhood-based maps are analysed based on 8-classes since the percentages of dissimilarities are aimed to keep under 2%. As it shows in Table 4.10, dissimilarity percentage within classes is 1,36% and similarity percentage between classes is 98,64% in 2010; 1,83% and 98,17% in 2014; 1,93% and 98,07% in 2018.

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,011	1,36%	0,000	1,83%	0,016	1,93%
Between-classes	0,831	98,64%	0,024	98,17%	0,790	98,07%
Total	0,843	100,00%	0,025	100,00%	0,806	100,00%

Table 4.10 Percentages of dissimilarities within and between 8-classes of neighbourhoods in Üsküdar.

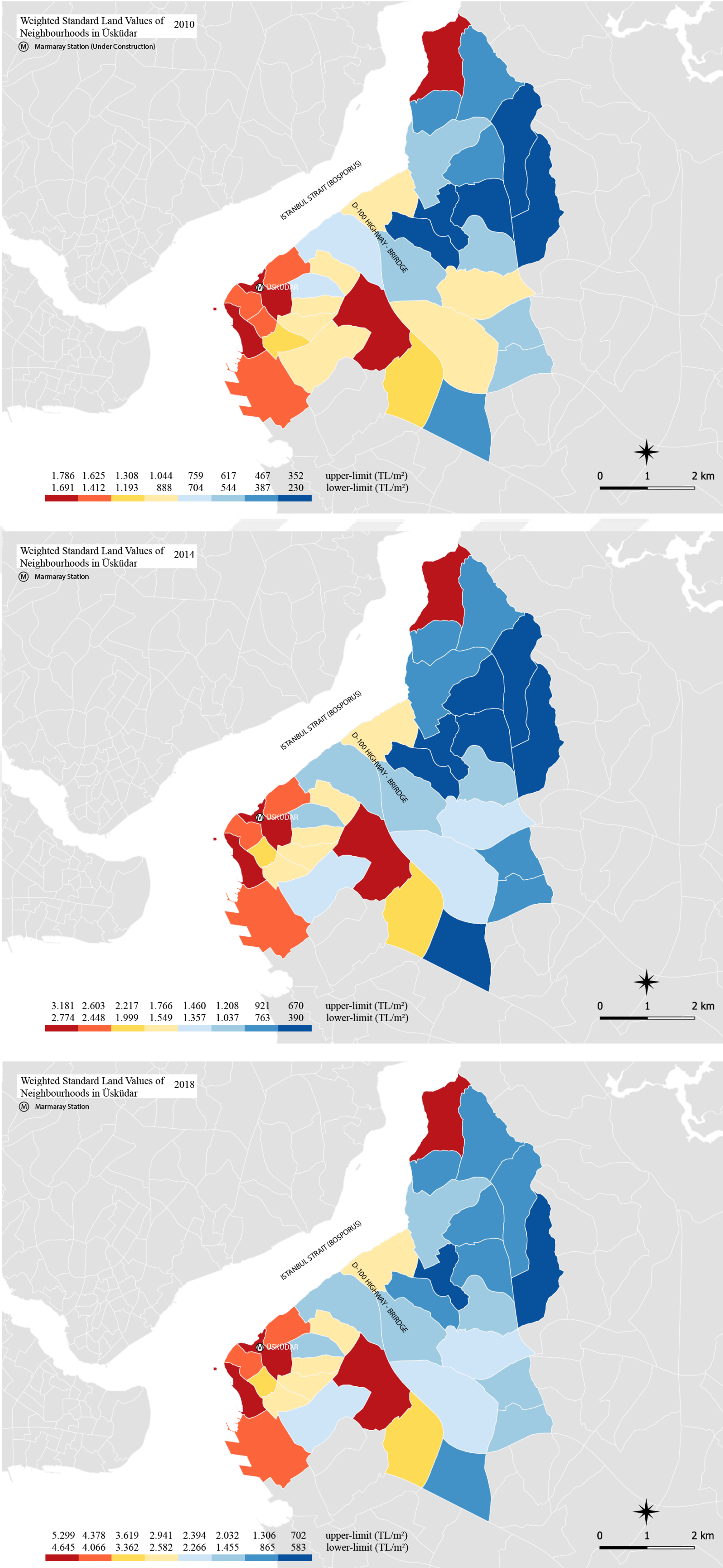

Figure 4.15. Neighbourhood-based maps of Üsküdar (2010-2014-2018)

Likely in Fatih, on the neighbourhood-based maps (*Figure 4.15*), it is not observed perceptibly changes between the case periods in terms of the distribution of weighted average land values of the neighbourhoods. Neighbourhoods that are weighted in the higher-valued classes are represented mostly in the south part of the district whereas those in the north part mostly represents the lower-valued classes. These three maps demonstrate that the density of neighbourhoods that are weighted and grouped in the highest and distinctively higher-valued groups are distributed around the Üsküdar train station. It should be kept in mind that there was no train system in 2010 but the construction of it has been carried out. Regardless of operation of the Marmaray system, this area displays the relatively higher average values than the rest of the district.

For the street-based analysis, 9-classes are specified due to percentage of dissimilarity level. In this context, percentages of dissimilarities within classes are 1,45% in 2010; 1,06% in 2014; and 0,98% in 2018 while the percentages of similarities are 98,55% in 2010; 98,94% in 2014; and 99,02% in 2018 (Table 4.11). Results meet the expectations of the analysis. Also, in order to specify the areas for the street-based analysis, train stations-centred 2-km radius areas are specified for the street-based analysis. In this context, 15-neighbourhoods in Üsküdar are taken into the analysis (Figure 4.16).

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,000	1,45%	0,018	1,06%	0,000	0,98%
Between-classes	0,002	98,55%	1,697	98,94%	0,002	99,02%
Total	0,002	100,00%	1,715	100,00%	0,002	100,00%

Table 4.11 Percentages of dissimilarities within and between 9-classes of standard land values of streets in Üsküdar.

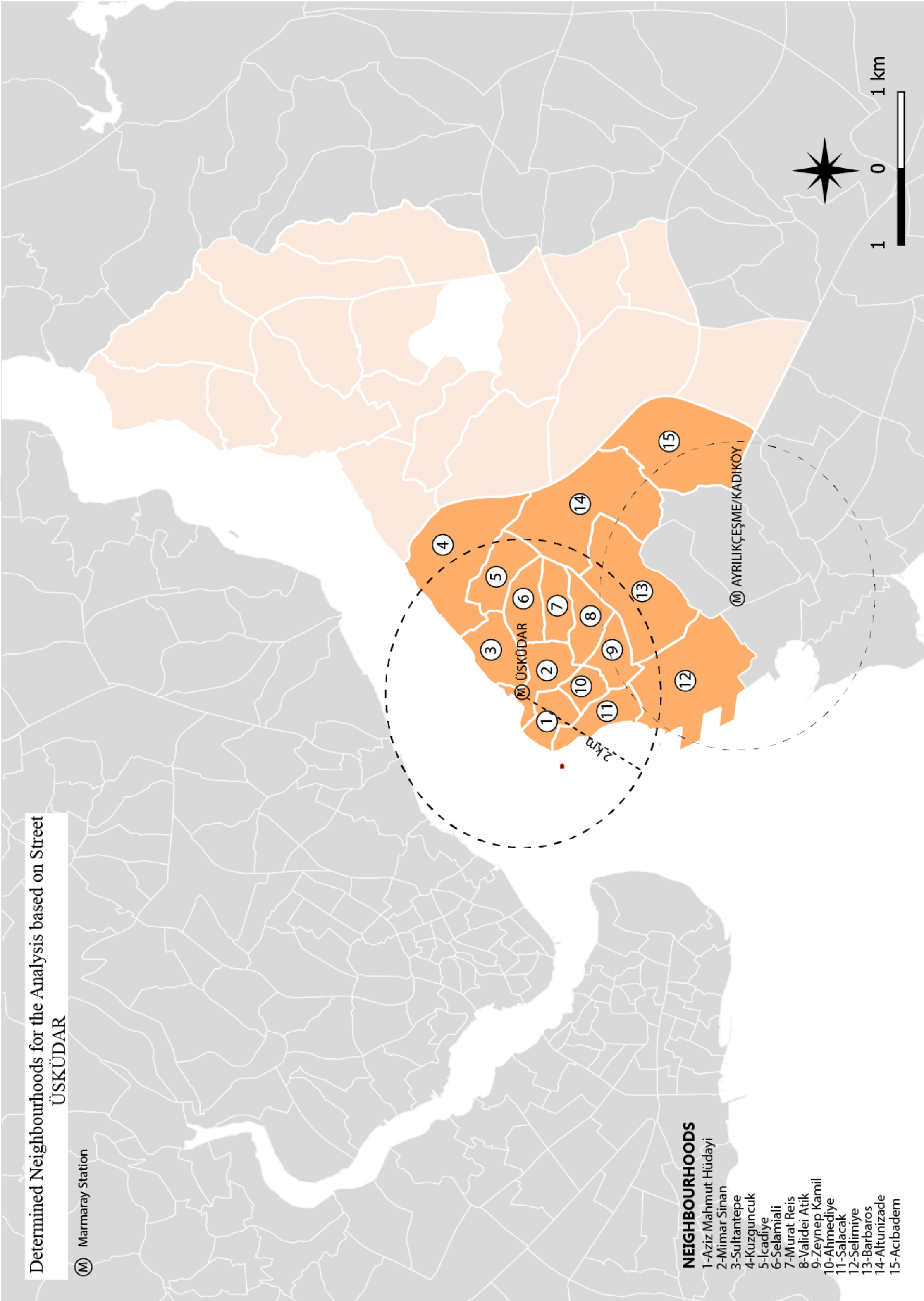

Figure 4.16. Scope area in Üsküdar

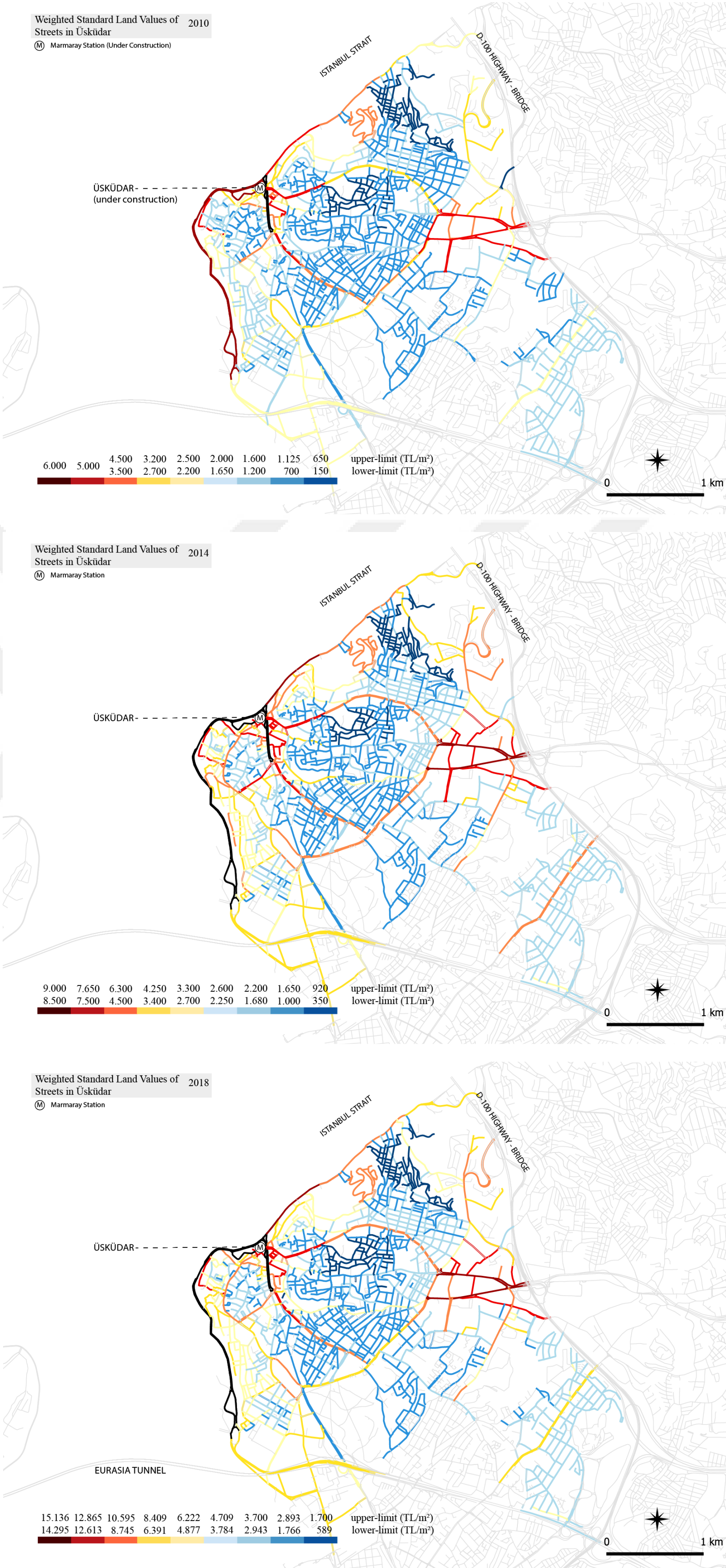

Figure 4.17. Street-based maps of Üsküdar (2010-2014-2018)

Street-based maps of Üsküdar (*Figure 4.17*) reveal some significant insights. To start with the map of 2010 (*Figure 4.17*), the streets where lie near the seashores are grouped in the relatively higher-valued classes whereas the back streets are weighted in the lower-valued classes. On the map of 2010, medium-level-valued classes are observed less than amount of high and low levels. Further, it monitors some observable changes in 2014 when the Üsküdar train station started operation. According to the map of 2014 (*Figure 4.17*), weights of the streets where lie around the Üsküdar train station change and so, increase observably. In other words, the station becomes a hotspot which creates a magnitude impacting the location. As it shows in Section.2 (Figure 2.4), the station acts as an attractive point that influences those that are placed in a magnitude sphere. Thus, the weighted values of those around the station are grouped in higher-valued classes in 2014. Also, observable changes are seen on the main axes. The map of 2018 (*Figure 4.17*) does not show major changes. Distribution of weighted values is almost the same with 2014.

4.7 Kadıköy

As it says in Section.3, noticeable settlement growths in Kadıköy have started to be established in parallel with the growth of transportation systems throughout history. The first phase of the Istanbul-Baghdad Railway System which has created the base of the suburban train system of the Asian Side has led rapid urban development over the area. Kadıköy, in this context, is where the start-point of the suburban train system of the Asian Side. The differences between the old suburban train line and the Marmaray are that there are some stations that have been newly implemented or removed. For instance, Haydarpaşa Stain has been a transportation hub where the lines of intra-city and inter-city trains end as well as the ferries have been landed. However, the Marmaray offers to pass over the Haydarpaşa Train Station and go over the Üsküdar as well as the Kızıltoprak Train Station has been removed in the new program. Also, Ayrılıkçeşme train station has been newly established through the implementation of the Marmaray and it has serviced as the start/endpoint of the first phase of the Marmaray.

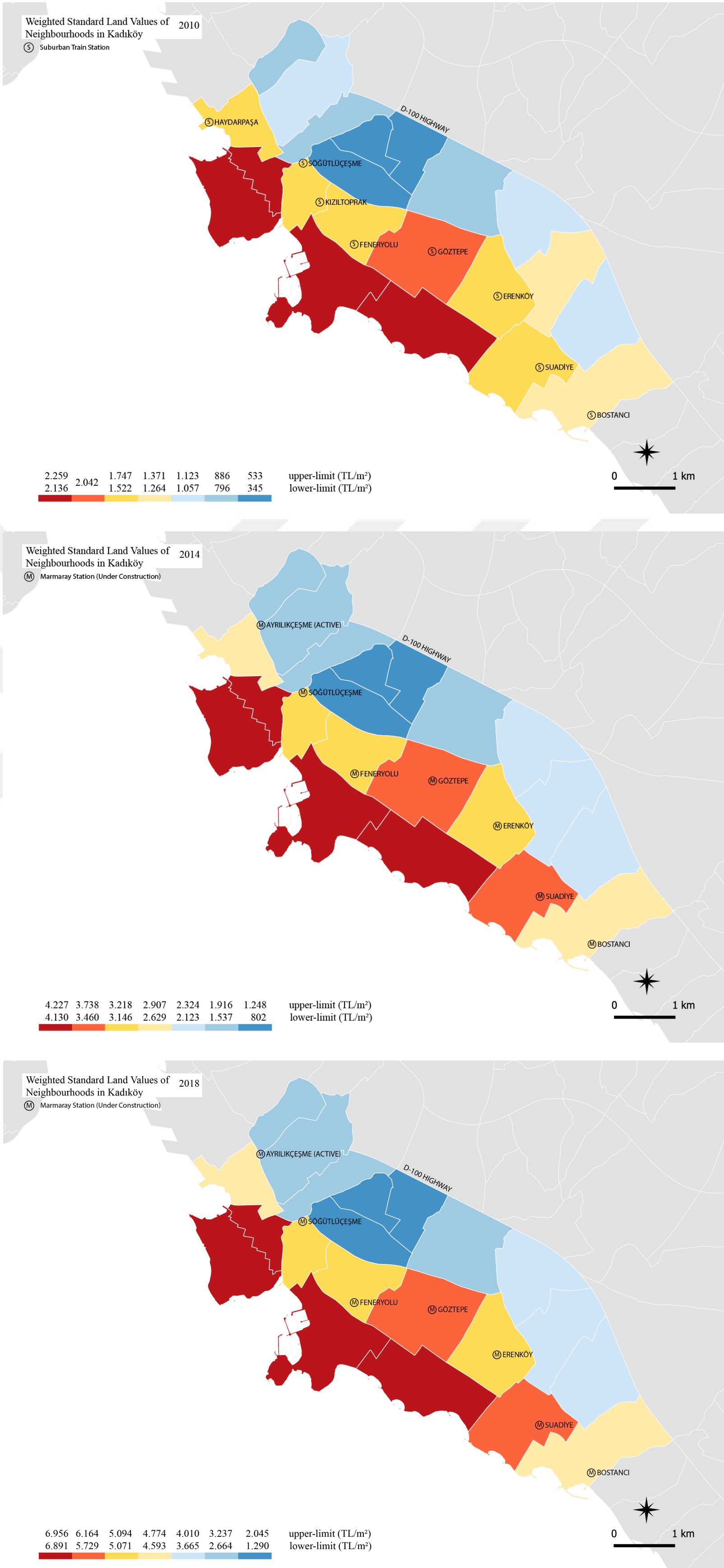

Figure 4.18. Neighbourhood-based maps of Kadıköy (2010-2014-2018)

The neighbourhood-based analysis is held based on 8-classes due to dissimilarity percentages. Calculations show that (Table 4.12) dissimilarity percentage of within classes is 1,27% in 2010; 1,89% in 2014; and 1,59% in 2018. In the same manner, the similarity percentage between classes is 98,73% in 2010; 98,11% in 2014; and 98,41% in 2018. Results fit expectations.

	2010		2014		2018	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,011	1,27%	0,016	1,89%	0,001	1,59%
Between-classes	0,880	98,73%	0,835	98,11%	0,038	98,41%
Total	0,891	100,00%	0,851	100,00%	0,038	100,00%

Table 4.12 Percentages of dissimilarities within and between 7-classes of neighbourhoods in Kadıköy.

According to the neighbourhood-based maps (*Figure 4.18*), it is not observed major changes. Weighted average land values of the neighbourhoods are distributed along the same line except for minor changes. In other words, similarities and dissimilarities between the spatial data in Kadıköy do not show a major change. On the maps, it displays that the neighbourhoods where are along the seashore represent the highest-valued classes; whose where lie between the seashore neighbourhoods and the D-100 Highway represent the middle-valued classes; and those where border on the D-100 Highway represent the lowest-valued classes.

Unlike the neighbourhood-based maps, street-based maps offer more detailed results which can be observed the areal changes. Firstly, the percentages of similarities and dissimilarities are calculated. In this sense, 9-classes based analysis is held. According to the results shown in Table 4.13, dissimilarity percentage within classes is 1,02% and similarity percentage between classes is 98,98% in 2010; 0,91% and 99,09% in 2014; and 0,81% and 99,19% in 2018. In this context, characteristics of streets are distinctively different from each other which can provide some significant insights. Besides, train stations-centred 2-km radius areas are specified for the street-based analysis in order to determine the areas for the analysis. In this context, all neighbourhoods in Kadıköy are taken into the analysis (Figure 4.19).

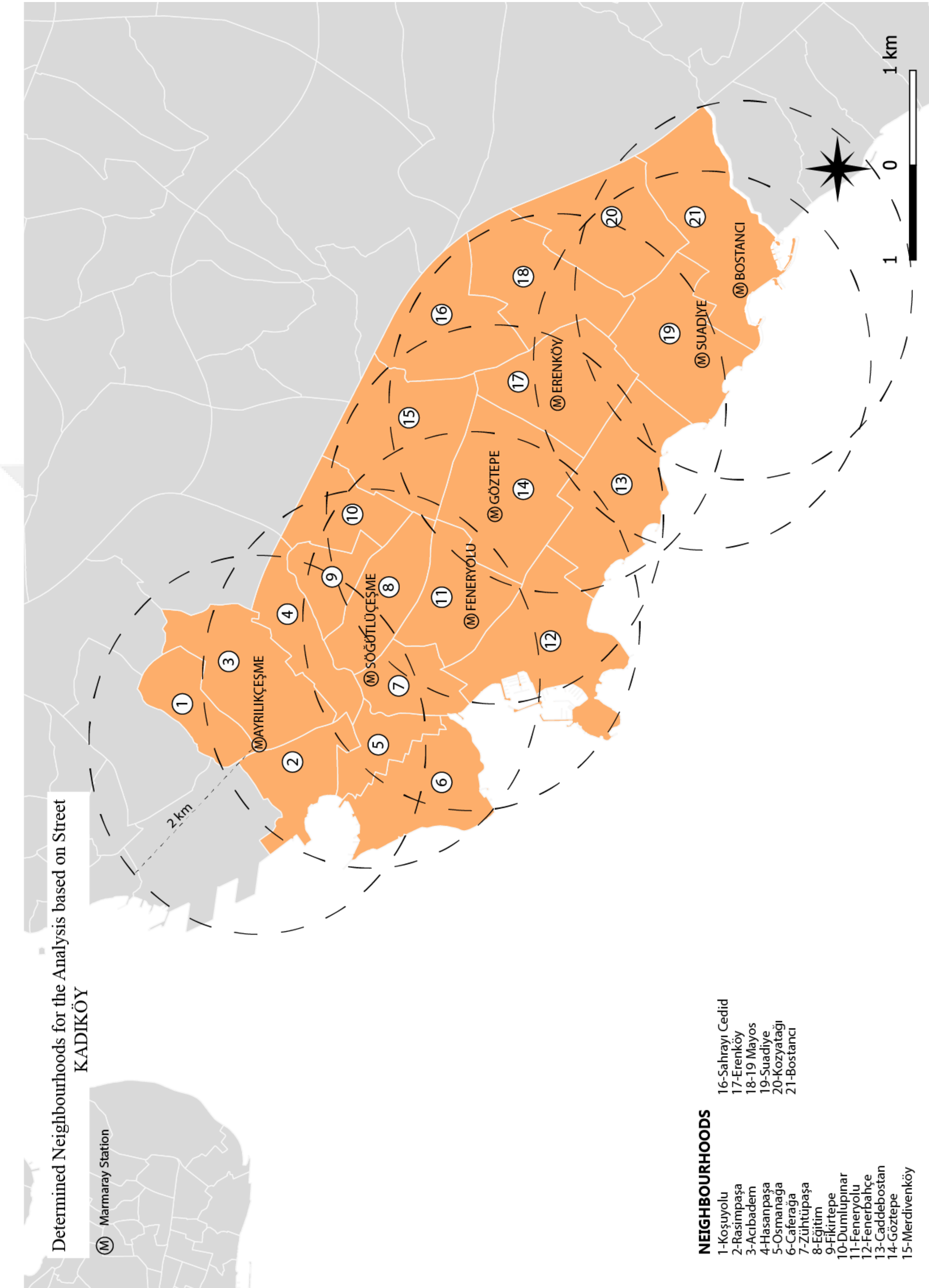

Figure 4.19. Scope area in Kadıköy

	2010		2014		2018	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,015	1,02%	0,000	0,91%	0,012	0,81%
Between-classes	1,454	98,98%	0,001	99,09%	1,507	99,19%
Total	1,469	100,00%	0,001	100,00%	1,519	100,00%

Table 4.13 Percentages of dissimilarities within and between 9-classes of standard land values of streets in Kadıköy.

The street map of 2010 (*Figure 4.20*) shows that the main axes represent the darkest colours within the highest valued classes. Streets between the D-100 and the second-degree main street just below the highway, are grouped in the lower and the lowest-valued classes. The area where the darkest blued streets are gathered is where the informal settlements occur. The colour degrees gradually change from the highway towards the seashore. Further, the streets around the train stations display the upper-middle and relatively higher-valued classes in comparison with the northern part.

Unlike the neighbourhood-based maps, street maps reveal some observable changes. From this point forth, unexpected results are offered on the street-based map of 2014 (*Figure 4.20*). Due to no operation of suburban train system after 2013, it is expected to change the matrices of value distribution. Further, changes of values show that the streets around the closed stations are grouped in relatively upper classes than those in 2010. These are sighted in the areas where are around Erenköy, Suadiye and Bostancı stations. Also, the core part of Kadıköy where is located below Söğütlüçeşme are grouped in noticeable higher-valued classes. It should not be forgotten that a rapid urban transformation process is held in Kadıköy just after the Law Transformation of Areas under the Disaster Risks which come into force in 2012 so to renew and rehabilitate the old and damaged building environment. Kadıköy is one of the districts that faces this rapid transformation. Although, the stations are still closed in 2018, however, the effects of the urban transformation process come into view on the street map of 2018 (*Figure 4.20*).

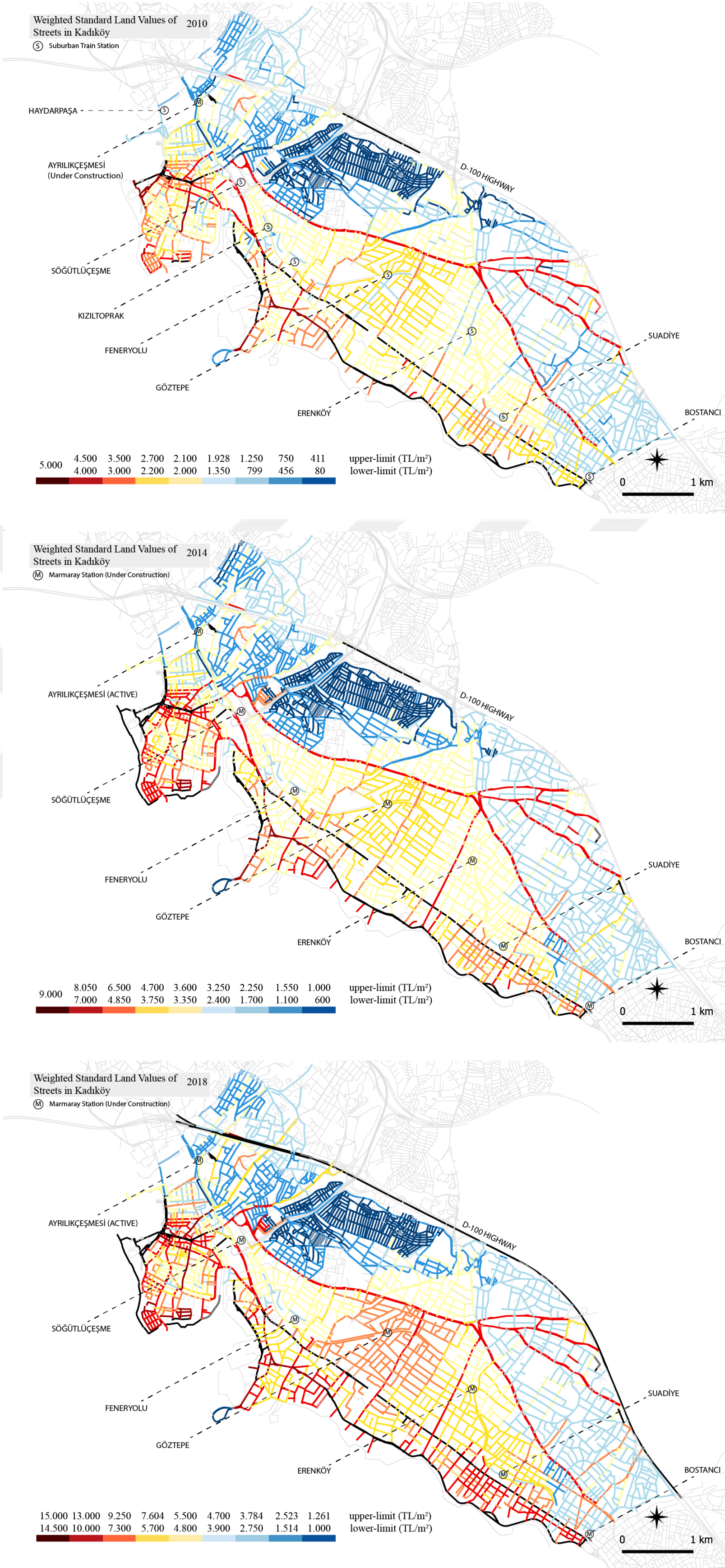

Figure 4.20. Street-based maps of Kadıköy (2010-2014-2018)

In this context, the areas around Göztepe, Erenköy and Suadiye stations and near the seashore are where the observable changes in terms of classifications occur. Thus, the streets in these areas are grouped in relatively higher-valued classes in 2018. Apart from these findings, the main axes still represent the highest-valued class, as well as the other parts of Kadıköy, still represent the same distribution of classes. In brief, the impacts of the absence of the suburban train system are poor in the Kadıköy case. Rather, urban transformation process predominantly impacts the classification in Kadıköy. Another significant point that reveals in Kadıköy case is that although, the major changes are not observed on the neighbourhood-based analysis, however, the detailed findings are provided through the findings on the street-based maps.

4.8 Maltepe

Maltepe is a district that is bordered by Kadıköy from northwest and Kartal from the southeast. As it shows on general view maps (*Appendix A*), neighbourhoods in Maltepe represent the lower-middle-valued classes in comparison with other neighbourhoods in Istanbul. According to the 7-classes based neighbourhood analysis, dissimilarity percentage is 0,59% within classes and similarity percentage is 99,41% between classes in 2010; percentage is 0,85% within classes and similarity percentage is 99,15% between classes in 2014; percentage is 0,85% within classes and similarity percentage is 99,15% between classes in 2018 (Table 4.14). So, the percentages satisfy expectations of the analysis.

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,000	0,59%	0,000	0,85%	0,000	0,85%
Between-classes	0,049	99,41%	0,048	99,15%	0,049	99,15%
Total	0,050	100,00%	0,049	100,00%	0,049	100,00%

Table 4.14 Percentages of dissimilarities within and between 7-classes of neighbourhoods in Maltepe.

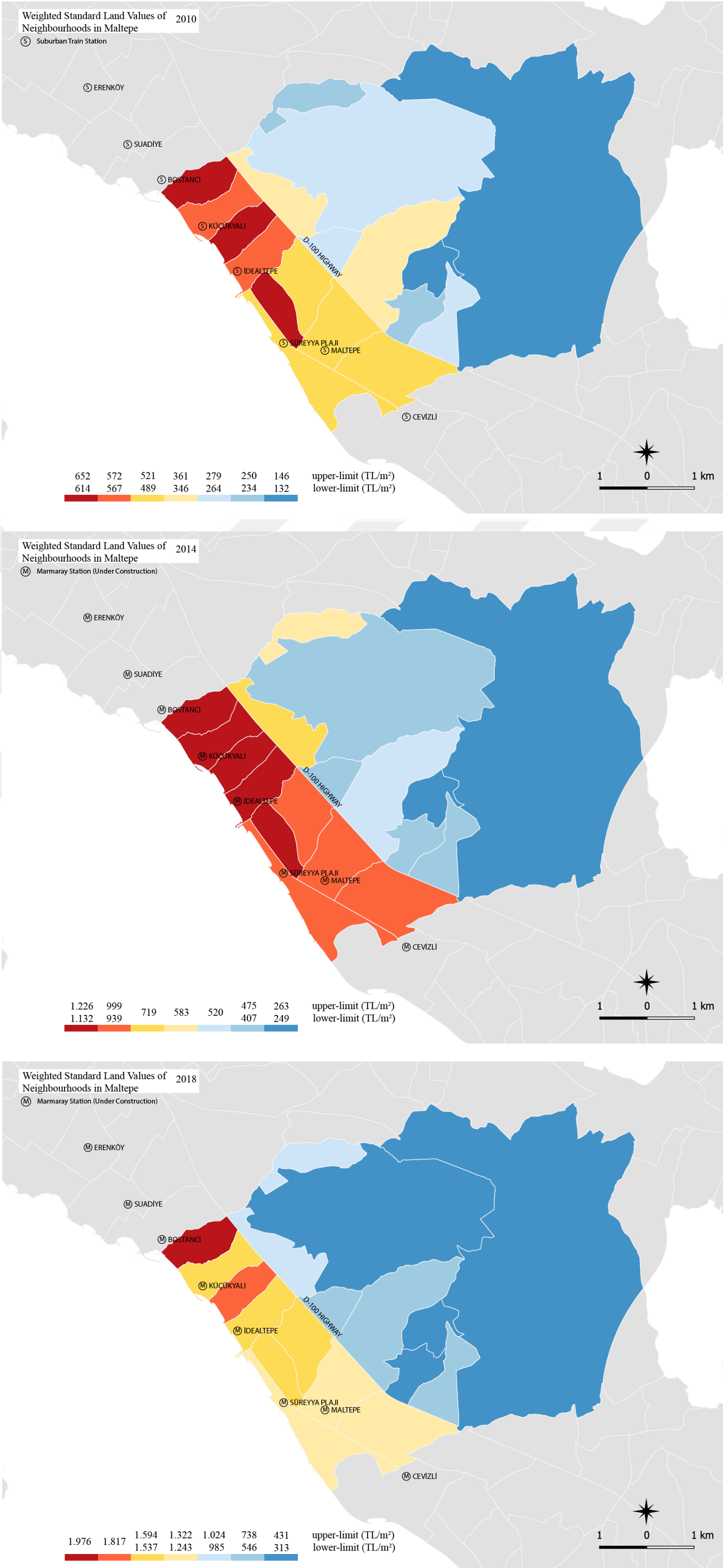

Figure 4.21. Neighbourhood-based maps of Maltepe (2010-2014-2018)

Maps of 2010 (*Figure 4.21*) shows a distinction between the upper and lower part of the district that are split by the D-100 Highway. In this way, the upper part represents predominantly lower values classes than the middle-valued ones whereas the bottom part where the neighbourhoods meet the seashore represent the above average and highest-valued classes. The bottom area is also where the suburban train stations are located.

Neighbourhood-based Maltepe maps provide some unexpected findings as those that are provided in Kadıköy case. According to the findings on the map of 2014 (*Figure 4.21*) when the suburban train system does not work, those are in the bottom part of the D-100 Highway are grouped in the higher-valued classes as well as some of the parts do the same in the upper part of the D-100. It is normally expected the neighbourhoods to be grouped in lower-valued classes. Rapid urban transformation process might be associated with this unexpected change. Besides, characteristics of distinction of value distributions are the same with those in 2010; D-100 acts as a separator that splits the land values distinctively.

Such as the results of 2014, the map of 2018 (*Figure 4.21*) also reveals some findings that are not expected in Maltepe case. Except for two neighbourhoods, those where are in the bottom part of the D-100 are grouped 2-lower-valued classes and the spatial matrices change. In this case, only one neighbourhood (Altıntepe) that borders on Kadıköy district, represents the highest-valued class whereas majority of others in the same line represents the average and above-average valued classes. The upper part of the D-100 still shows the lowest-valued classes.

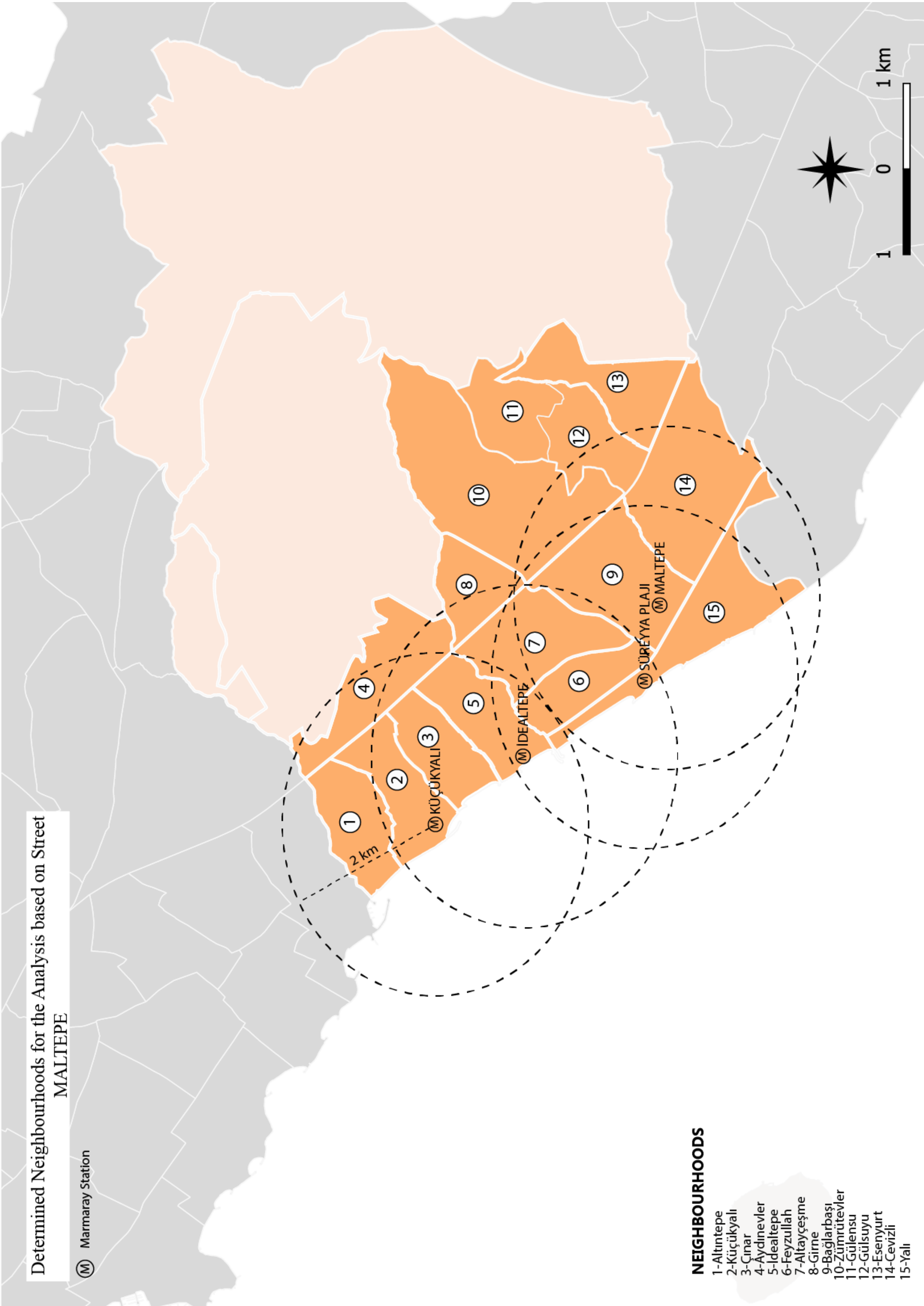

Figure 4.22. Scope area in Maltepe

Train stations-centred 2-km radius areas are specified for the street-based analysis in order to determine the areas for the analysis. In this context, 15-neighbourhoods in Maltepe are taken into the analysis except 3 of them from the north side that represent the lowest valued neighbourhood classes (Figure 4.22). According to the 9-classes based street analysis, dissimilarity percentage is 0,85% within classes and similarity percentage is 99,15% between classes in 2010; percentage is 0,74% within classes and similarity percentage is 99,26% between classes in 2014; percentage is 1,18% within classes and similarity percentage is 98,82% between classes in 2018 (Table 4.15). So, the percentages satisfy expectations of the analysis.

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,021	0,85%	0,016	0,74%	0,000	1,18%
Between-classes	2,489	99,15%	2,128	99,26%	0,002	98,82%
Total	2,510	100,00%	2,144	100,00%	0,002	100,00%

Table 4.15 Percentages of dissimilarities within and between 9-classes of standard land values of streets in Maltepe.

Findings from street-based map of 2010 (*Figure 4.23*) depict that highest-valued streets are represented on the main axes including coastal road and the D-100. The upper part of the D-100 represents the lowest-valued streets whereas the bottom part of it represents above-average valued classes. The streets around the suburban train stations display relatively higher values with the darker colours. Street-based map of 2014 (*Figure 4.23*) provides some observable changes. There has been no train system until the Marmaray system was opened in 2019. Absence of the suburban train system can be sighted through the streets around and close by the stations. On the one hand, the upper part of the D-100 does not show major changes. On the other hand, the bottom part of the highway displays some major changes. Especially, the zones between the station and the D-100 are grouped in more than 1-lower-valued groups and distribution of blue tones are predominantly seen. Further, map of 2018 (*Figure 4.23*) reveals that the zones between the coastal road and the first further main axis occur majorly lower groups in comparison those in 2014, as well as the upper parts of these zones, represents also lower groups. Three maps also show that the main axes always represent the highest-valued classes.

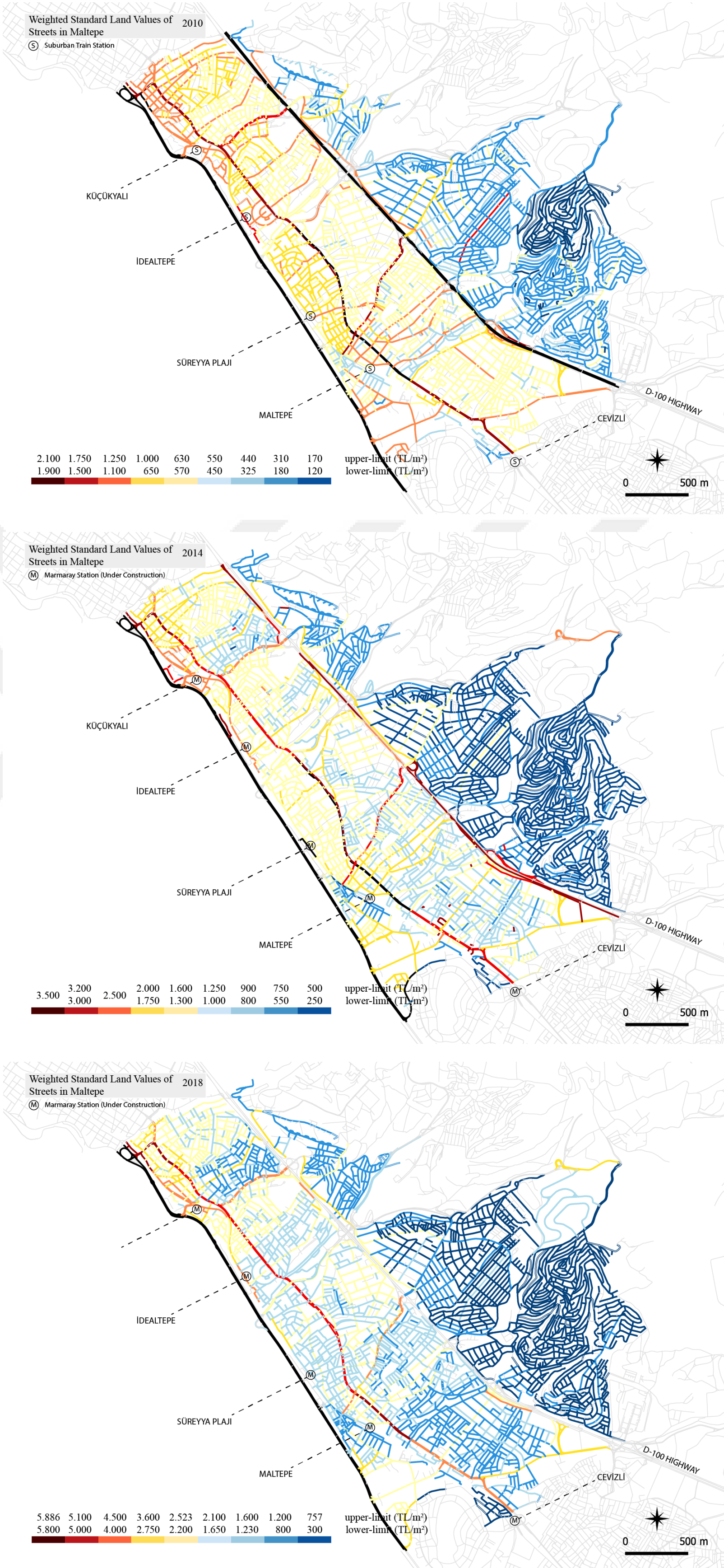

Figure 4.23. Street-based maps of Maltepe (2010-2014-2018)

4.9 Kartal

Kartal is a district where lies between Maltepe and Pendik districts. According to the general view maps (*Appendix A.*), Kartal is in the lower-middle-valued classes in comparison with the rest of the neighbourhoods in Istanbul. Based on 7-classes neighbourhood analysis, dissimilarity percentage within classes is 0,63% in 2010; 1,06% in 2014 and 2,27% in 2018. Also, similarity percentage between classes is 99,37% in 2010; 98,94% in 2014; and 97,73% in 2018 (Table 4.16).

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,005	0,63%	0,009	1,06%	0,001	2,27%
Between-classes	0,723	99,37%	0,801	98,94%	0,037	97,73%
Total	0,728	100,00%	0,810	100,00%	0,038	100,00%

Table 4.16 Percentages of dissimilarities within and between 7-classes of neighbourhoods in Kartal.

Neighbourhood-based average land values map of 2010 (*Figure 4.24*) displays that weight of higher-valued classes are distributed along the seaside and the suburban train stations. Neighbourhoods, where are located inner-parts, represent relatively lower-valued classes. Unexpectedly, the distribution of classification matrices changes on the map of 2014 (*Figure 4.24*). According to the findings, those where are located between the highest valued neighbourhood and the D-100 are grouped mostly in 2-upper-valued classes as well as some of them where are located upper part of the D-100 are also grouped in 2-upper-valued classes. Furthermore, most of the neighbourhoods that are grouped in relatively higher-valued classes, are grouped in lower-valued classes as it shows on the map of 2018 (*Figure 4.24*). In order to observe detailed findings, train stations-centred 2-km radius areas are specified for the street-based analysis. In this context, 12-neighbourhoods in Kartal are taken into the analysis (Figure 4.25).

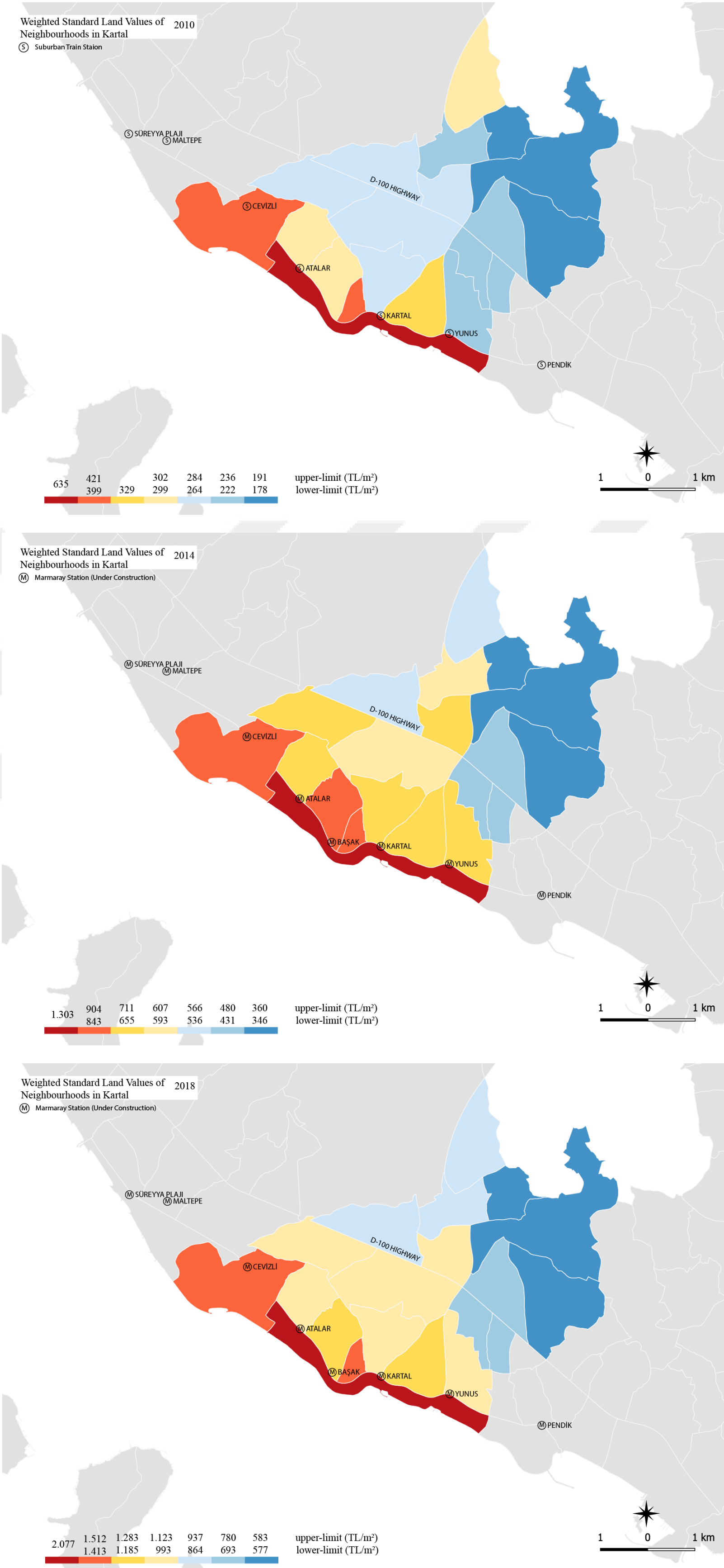

Figure 4.24. Neighbourhood-based maps of Kartal (2010-2014-2018)

Based on 9-classes street analysis, dissimilarity percentage within classes is 1,02% in 2010; 0,87% in 2014 and 0,83% in 2018. Also, similarity percentage between classes is 98,98% in 2010; 99,13% in 2014; and 99,17% in 2018 (Table 4.17). In this case, dissimilarity percentages are quite low which means the profiles of the streets are distinct.

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,000	1,02%	0,000	0,87%	0,016	0,83%
Between-classes	0,002	98,98%	0,001	99,13%	1,909	99,17%
Total	0,002	100,00%	0,001	100,00%	1,925	100,00%

Table 4.17 Percentages of dissimilarities within and between 9-classes of standard land values of streets in Kartal.

Street-based maps reveal something that is not sighted on neighbourhood-based maps. As it shows on the map of 2010 (*Figure 4.26*), the streets around the suburban train stations are relatively higher than the other ones while the highest-valued classes are represented on the main axes and the coastal road. Differently, the map of 2014 (*Figure 4.26*) displays that the streets around the stations are grouped in lower-valued classes, unlike the ones in 2010. Apart from these streets, the rest of them still represents the lowest-valued classes, as well as the main axes, still represent the highest-valued classes in 2014. In comparison, it is observed minor changes on the street-based map of 2018 (*Figure 4.26*). For example, some of the main streets are grouped in relatively lower-valued classes where are located upper side of Atalar train station.

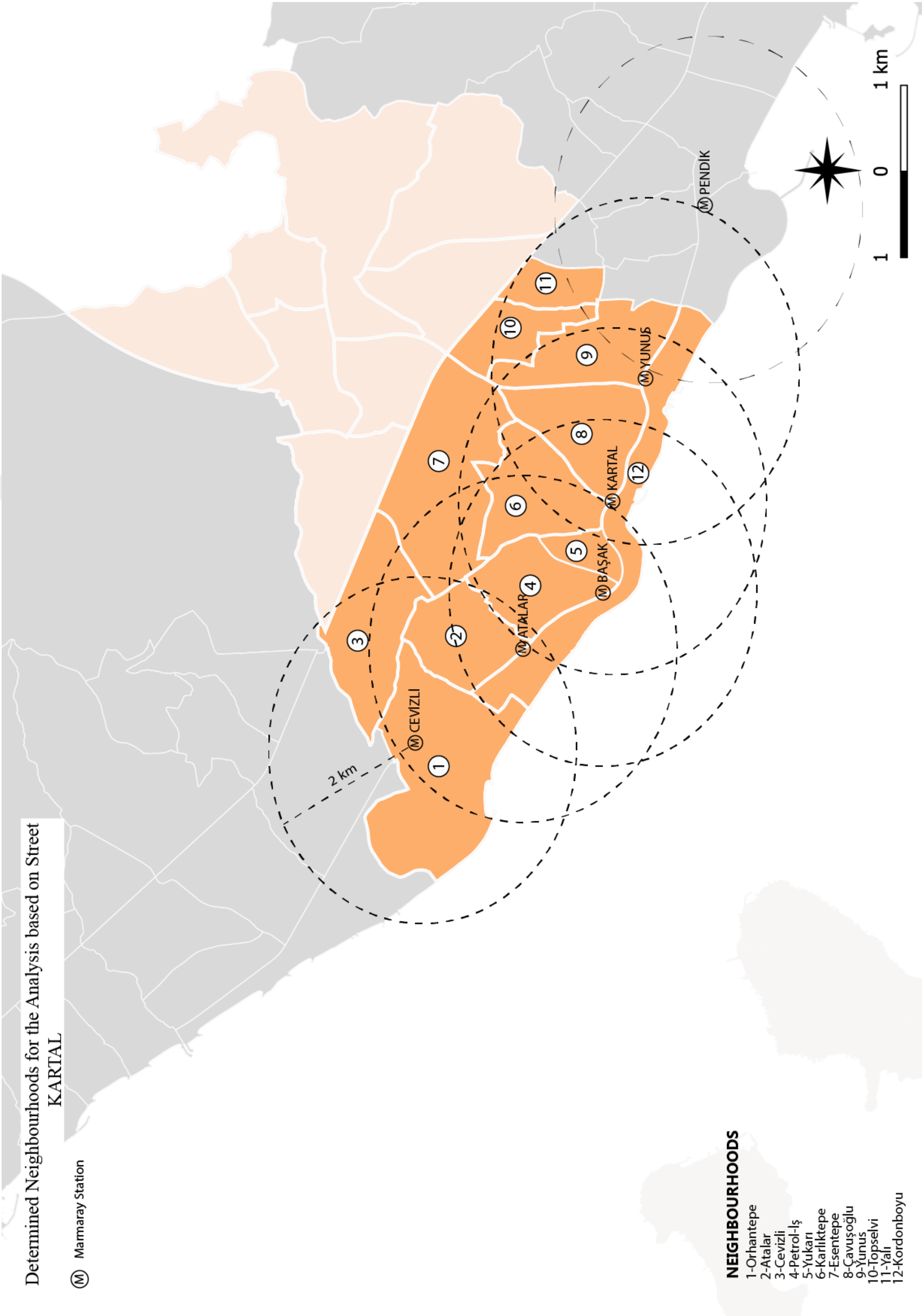

Figure 4.25 Scope area in Kartal

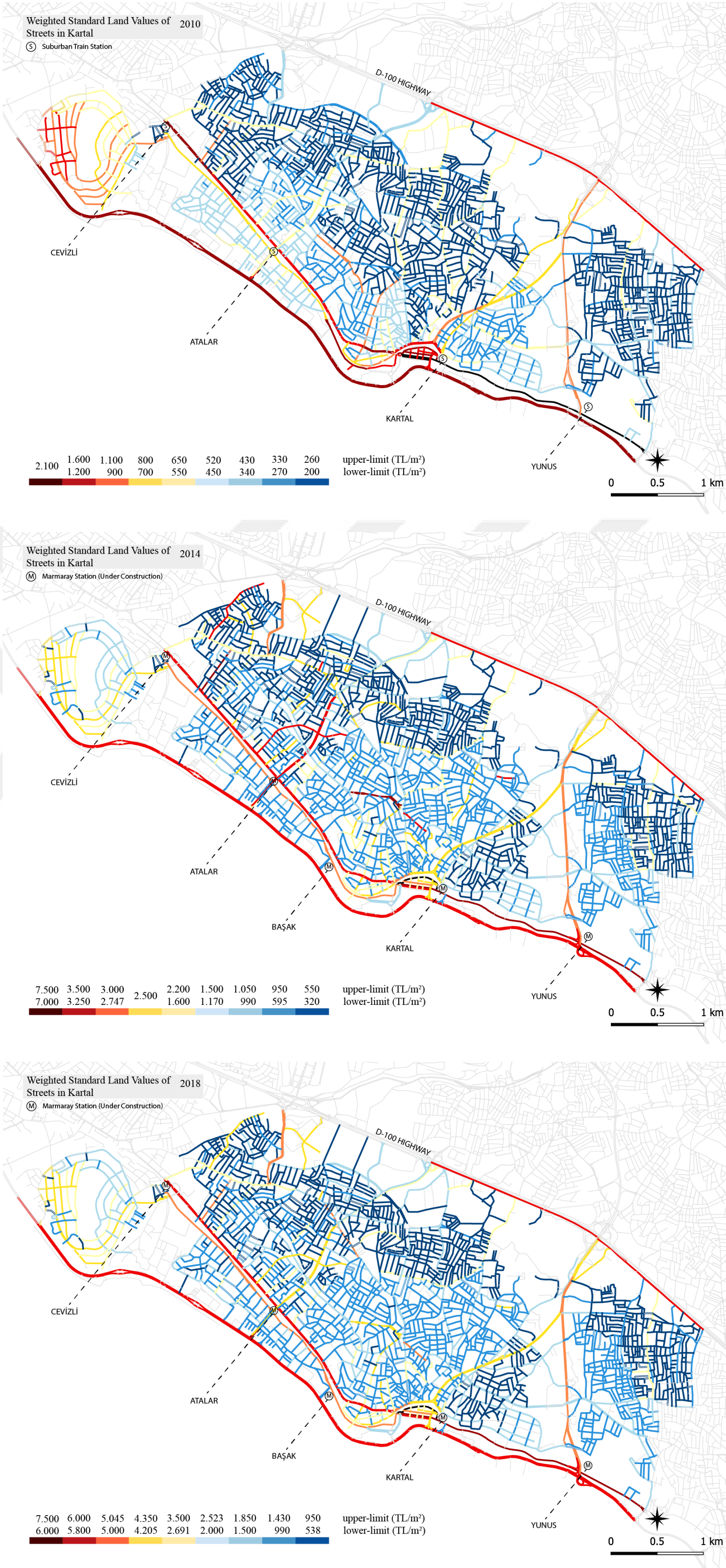

Figure 4.26. Street-based maps of Kartal (2010-2014-2018)

4.10 Pendik

Pendik stands next to the last district-Tuzla. Pendik, on the general view maps (*Appendix A*) always represents the lowest valued group in comparison with those representing throughout Istanbul. Based on 8-classes neighbourhood analysis, dissimilarity percentage within classes is 0,84% in 2010; 3,29% in 2014 and 2,61% in 2018. Also, similarity percentage between classes is 99,16% in 2010; 96,71% in 2014; and 97,39% in 2018 (Table 4.18). Although, the percentages do not meet the expectations, however, classification based on 8 groups are accepted since other analyses based on 9-groups also represent similar results. In this case, it can be interpreted that dissimilarity percentage within classes in 2014 is at the highest level. In other words, the classes those in 2010 and 2018 differ from each other more than those in 2014.

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,006	0,84%	0,000	3,29%	0,000	2,61%
Between-classes	0,735	99,16%	0,010	96,71%	0,011	97,39%
Total	0,742	100,00%	0,010	100,00%	0,012	100,00%

Table 4.18 Percentages of dissimilarities within and between 8-classes of neighbourhoods in Pendik.

Borders of Pendik reach out toward the big territories, unlike the other districts that have been analysed so far. It should be noted that the neighbourhoods that occur mass areas in the north part of Pendik do not contain dense settlements. Rather, they include empty slots. As a result of this, the north part of the district always represents the lowest valued classes on all neighbourhood-based maps (*Figure 4.27*). Besides, the average standard land values of classes are distinctively low in comparison with the others.

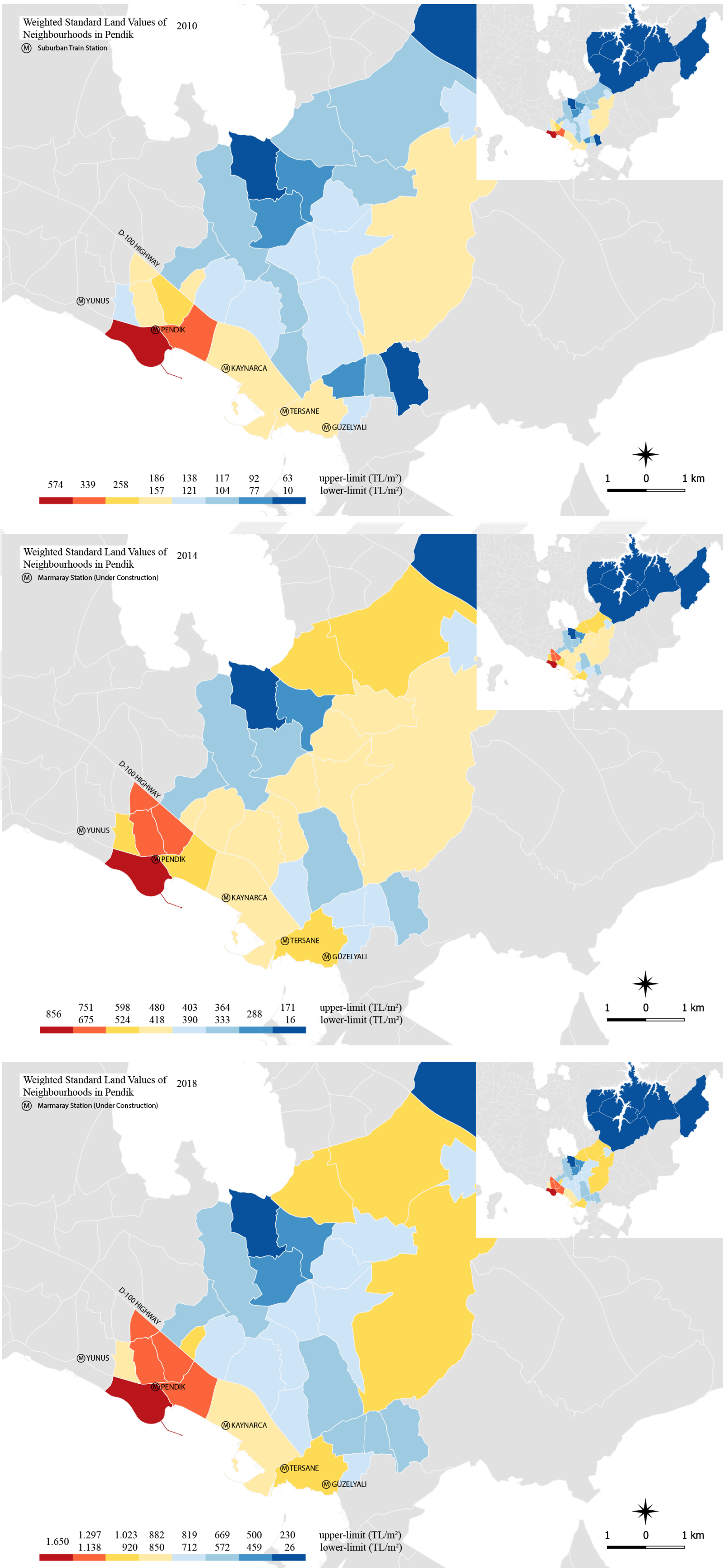

Figure 4.27. Neighbourhood-based maps of Pendik (2010-2014-2018)

Neighbourhood-based map of 2010 (*Figure 4.27*) shows that there is only one neighbourhood that is grouped in the highest-valued class that also holds the Pendik suburban train station. Other neighbourhoods along the seaside represent the middle-valued classes, as well as some other neighbourhoods, being inner side also represent the middle-valued classes. Majority of them are grouped in relatively lower and the lowest-valued groups.

Neighbourhood-based map of 2014 (*Figure 4.27)* reveals some unexpected results. According to this map, neighbourhoods in a large part of the inner Pendik are grouped in higher-valued classes. Those that are located in the edges of Pendik, bordered on Kartal and Tuzla are also grouped in higher-valued classes. Also, those that are located along the seaside still represent middle and upper-middle-valued classes. Unlikely, map of 2018 (*Figure 4.27*) shows that the neighbourhoods that are grouped in higher-valued classes in 2014, also are grouped in lower-valued classes in 2018. Therefore, the inner part of Pendik represents the blue tones which also represents lower-valued classes. Apart from this, the neighbourhoods locating along the seaside still represent middle-valued and relatively higher-valued classes.

In order to observe detailed findings, train stations-centred 2-km radius areas are specified for the street-based analysis. In this context, 19-neighbourhoods in Pendik are taken into the analysis (Figure 4.28). Based on 9-classes street analysis, dissimilarity percentage within classes is 1,39% in 2010; 1,49% in 2014 and 1,28% in 2018. Also, similarity percentage between classes is 98,61% in 2010; 98,51% in 2014; and 98,72% in 2018 (Table 4.19).

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,032	1,39%	0,025	1,49%	0,000	1,28%
Between-classes	2,268	98,61%	1,659	98,51%	0,001	98,72%
Total	2,300	100,00%	1,684	100,00%	0,001	100,00%

Table 4.19 Percentages of dissimilarities within and between 9-classes of standard land values of streets in Pendik.

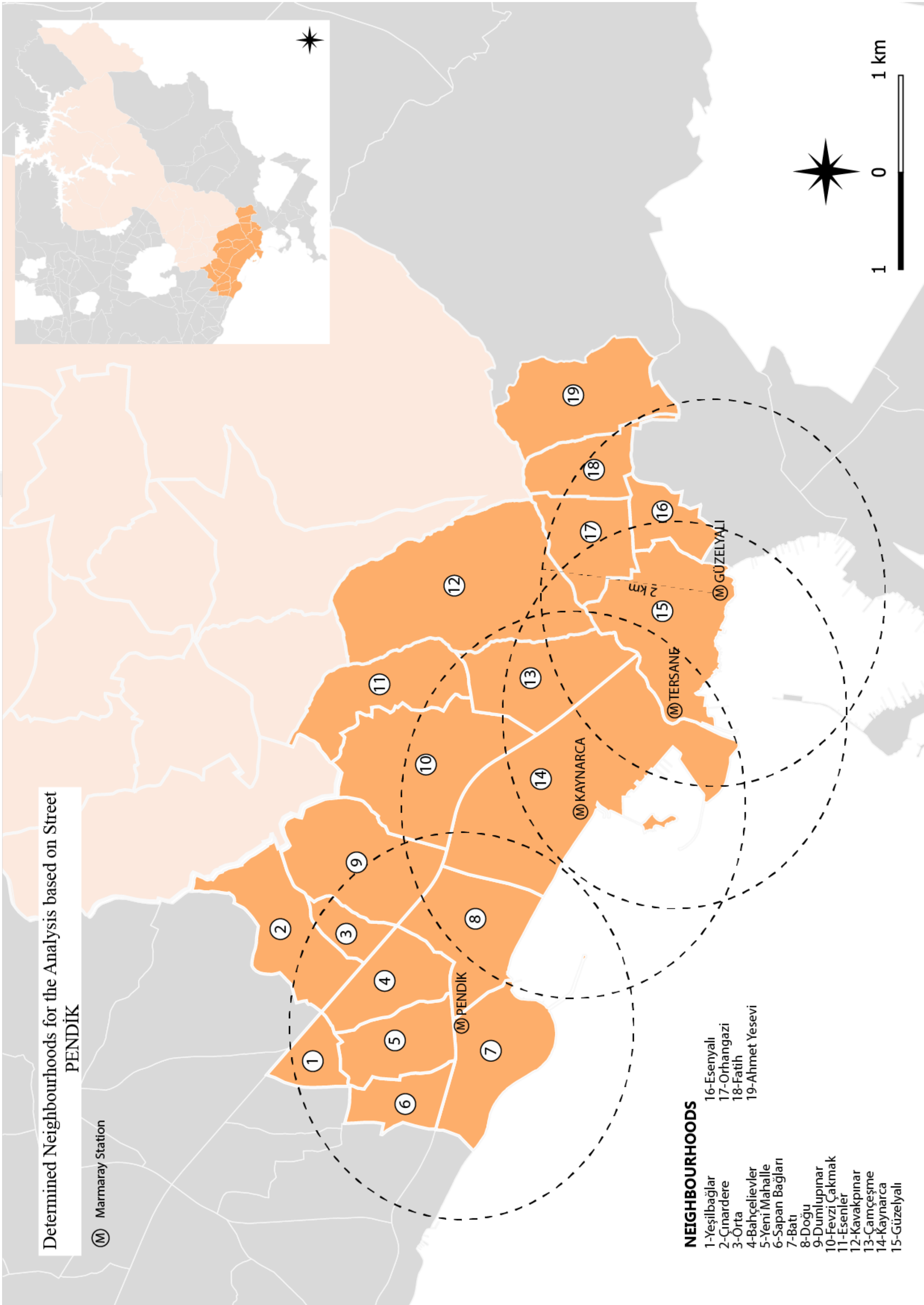

Figure 4.28. Scope area in Pendik

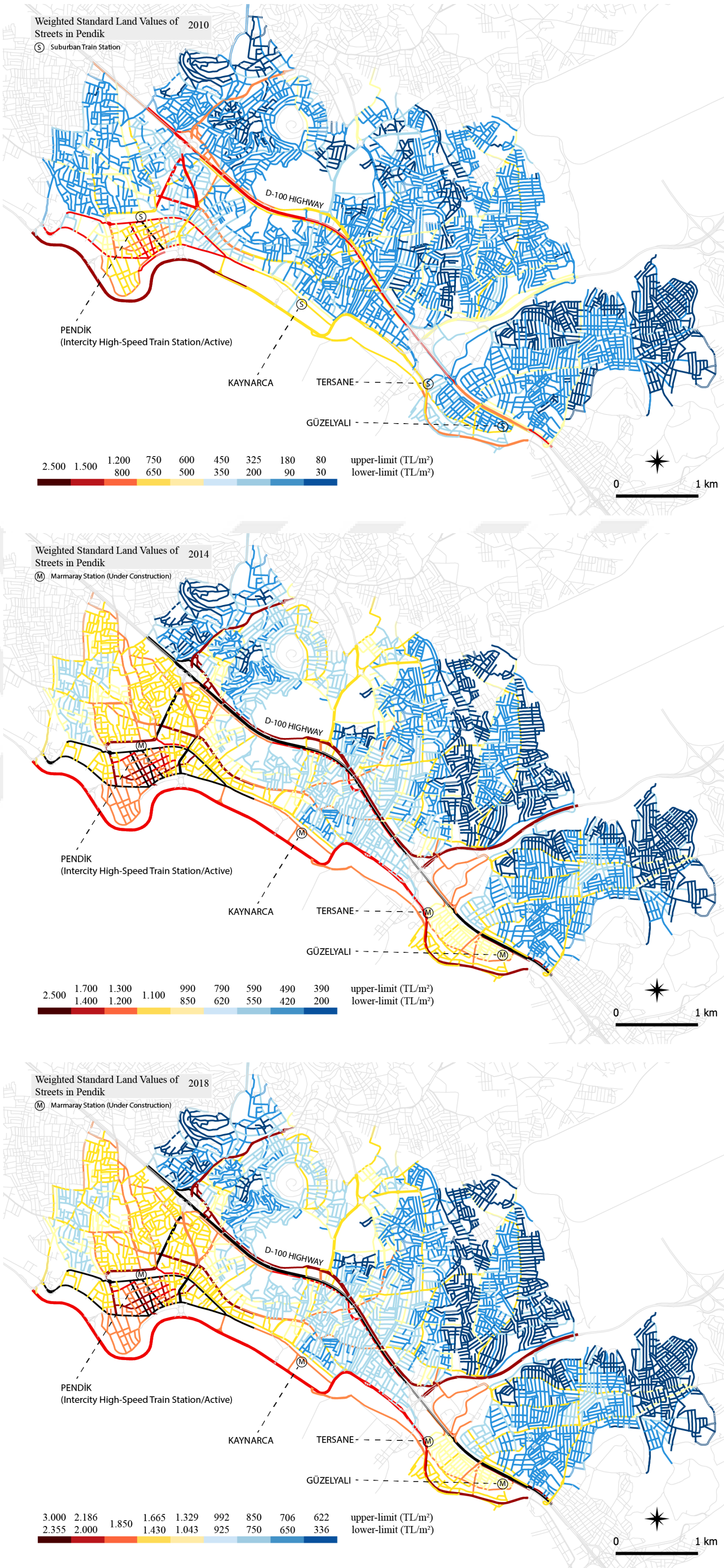

Figure 4.29. Street-based maps of Pendik (2010-2014-2018)

When specified areas are analysed, some unexpected results are revealed such in the ones on neighbourhood-maps. Street-based map of 2010 (*Figure 4.29*) monitors that a major part of streets is represented based on lowest-valued classes except for the main axes. In this case, the coastal road and the D-100 represent the highest valued classes while the streets around the Pendik suburban train station are grouped in also relatively higher-valued classes and the ones around the Kaynarca and Tersane stations are also grouped in upper-middle classes with yellow tones. When the streets in 2014 (*Figure 4.29*) are analysed, one significant point reveals. This is about standard land values. The highest amount of value of 2010 and 2014 is the same which is 2.500 TL whereas values of other classes are different. In the case of 2014, remarkable changes are observed in the areas around the Pendik train station. In 2014, although, there has been no suburban train system, however, a high-speed train system has been established in 2014 and Pendik train station is specified as the start point of it in Istanbul. Rest of the streets do not show major changes in terms of classification.

The map of 2018 (*Figure 4.29*) also shows some major changes. The streets around the Pendik train station accelerate to be valued and grouped in the higher valued classes. In this context, they represent the highest-valued classes in comparison with the other streets in Pendik. Therefore, this area is coloured with black, red and yellow tones. Besides, the streets between Tersane and Güzelyalı stations are also grouped in relatively higher-valued classes. Apart from this, the major part of analysed areas is grouped in relatively lower-valued groups in 2018.

4.11 Tuzla

Tuzla is a border district to Kocaeli Province. Territorial borders of Tuzla also reach the mass areas like Pendik. That is why the inner part of it always represents the lowest-valued classes, as well as the whole district, also represents the lowest-valued class with the dark blue on the general view maps (*Appendix A.*).

Neighbourhood-based maps are analysed based on 7-classes since the percentages of dissimilarities are aimed to keep under 2%. As it shows in Table 4.20, dissimilarity percentage within classes is 0,94% and similarity percentage between classes is 99,06% in 2010; 1,18% and 98,82% in 2014; 1,04% and 98,96% in 2018. Results meet expectations.

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,000	0,94%	0,009	1,18%	0,000	1,04%
Between-classes	0,048	99,06%	0,791	98,82%	0,040	98,96%
Total	0,048	100,00%	0,800	100,00%	0,040	100,00%

Table 4.20 Percentages of dissimilarities within and between 7-classes of neighbourhoods in Tuzla.

Neighbourhood-based map of 2010 (*Figure 4.30*) monitors that the highest-valued classes are located along the seaside whereas the inner part of Tuzla represents relatively lower-valued classes. There is no observable major change of distribution of average land values of neighbourhoods when all the cases are analysed. In this context, the map of 2014 (*Figure 4.30*) shows that inner parts of Tuzla gained values in terms of the distribution of average land values. Also, ones around the old suburban train systems are grouped in relatively lower-valued groups. Map of 2018 (*Figure 4.30*) also does not provide any significant changes. Only two neighbourhoods from the inner part of the district and the one that is the upper side of the İçmeler station are grouped in relatively lower-valued classes. The neighbourhood that is located in the peninsula represents the highest-valued class with red colour in 2014 and 2018 whereas it represents a distinctively higher class with orange colour in 2010.

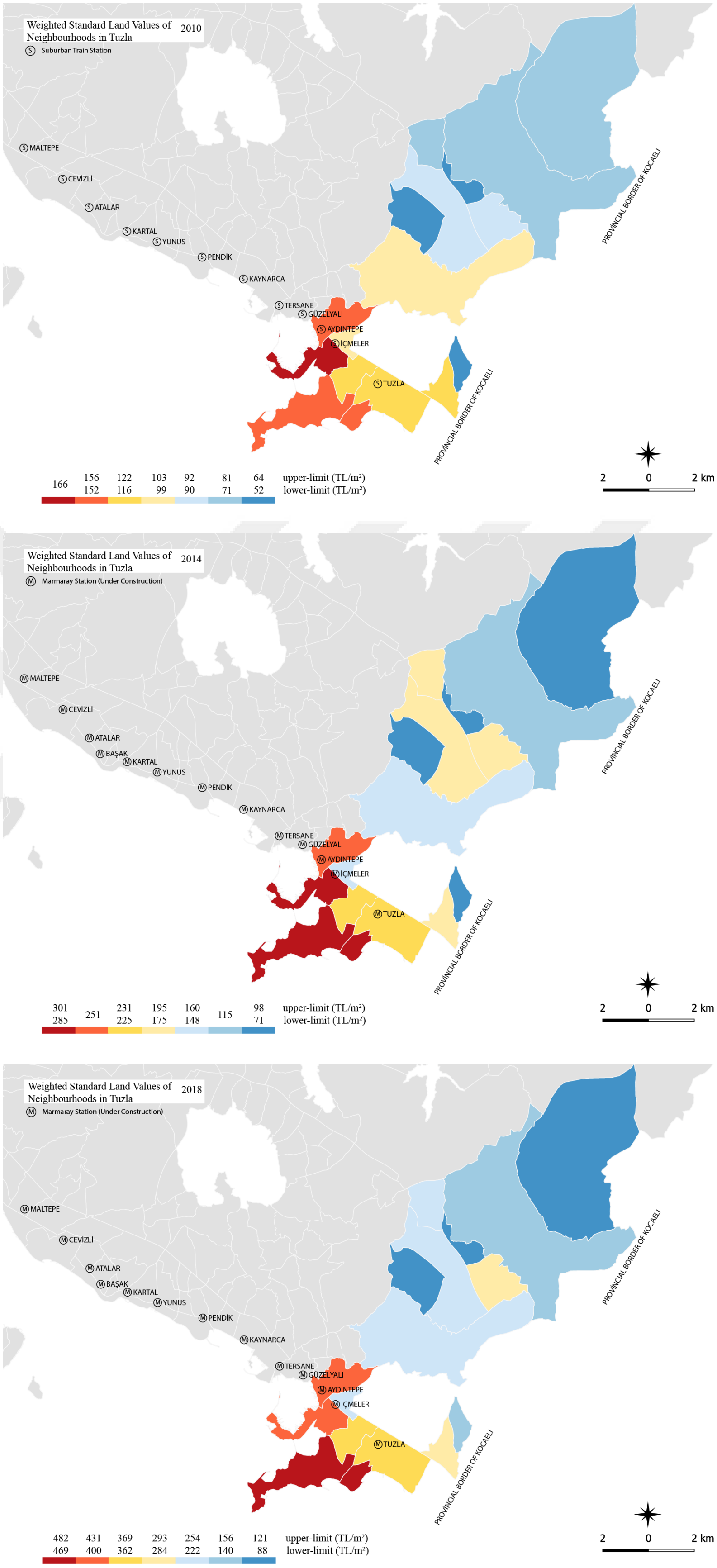

Figure 4.30. Neighbourhood-based maps of Tuzla (2010-2014-2018)

Train stations-centred 2-km radius areas are specified for the street-based analysis in order to determine the areas for the analysis. In this context, 7-neighbourhoods in Pendik are taken into the analysis (*Figure 4.31*). Based on 9-classes street analysis, dissimilarity percentage within classes is 0,58% in 2010; 1,09% in 2014 and 1,24% in 2018. Also, similarity percentage between classes is 99,42% in 2010; 98,91% in 2014; and 98,76% in 2018 (Table 4.21).

	2010		**2014**		**2018**	
	Absolute	Percent	Absolute	Percent	Absolute	Percent
Within-class	0,009	0,58%	0,000	1,09%	0,018	1,24%
Between-classes	1,521	99,42%	0,001	98,91%	1,475	98,76%
Total	1,530	100,00%	0,001	100,00%	1,494	100,00%

Table 4.21 Percentages of dissimilarities within and between 9-classes of standard land values of streets in Tuzla.

Street-based maps provide some insights that are not observed on the neighbourhood-based maps of Tuzla. In this context, the map of 2010 (*Figure 4.32*) reveals that the streets that are grouped in highest-valued classes are distributed around the suburban train stations, in particular Aydıntepe and İçmeler stations. The ones around the Tuzla station do not represent the highest-valued classes as much as others. The streets in the peninsula represent middle-valued classes. The significant point is that the map of 2014 (*Figure 4.32*) provides that the streets that are located upper part of Aydıntepe station are grouped in relatively lower-valued classes. Rest of them does not show major changes. Further, major changes are held on the street-based map of 2018 (*Figure 4.32*).

According to the map of 2018, the upper part of the Aydıntepe station shows some minor changes and they are grouped in relatively lower-valued classes. At the same time, the streets in the large part of the peninsula and the core part of Tuzla between the Tuzla and İçmeler stations represent relatively higher-valued classes in comparison with those in 2014. In brief, the weight of higher-valued-classes move to the streets that are in the peninsula and the core part of Tuzla, even though the area around İçmeler and Aydıntepe stations still represents the highest-valued classes with the red tones.

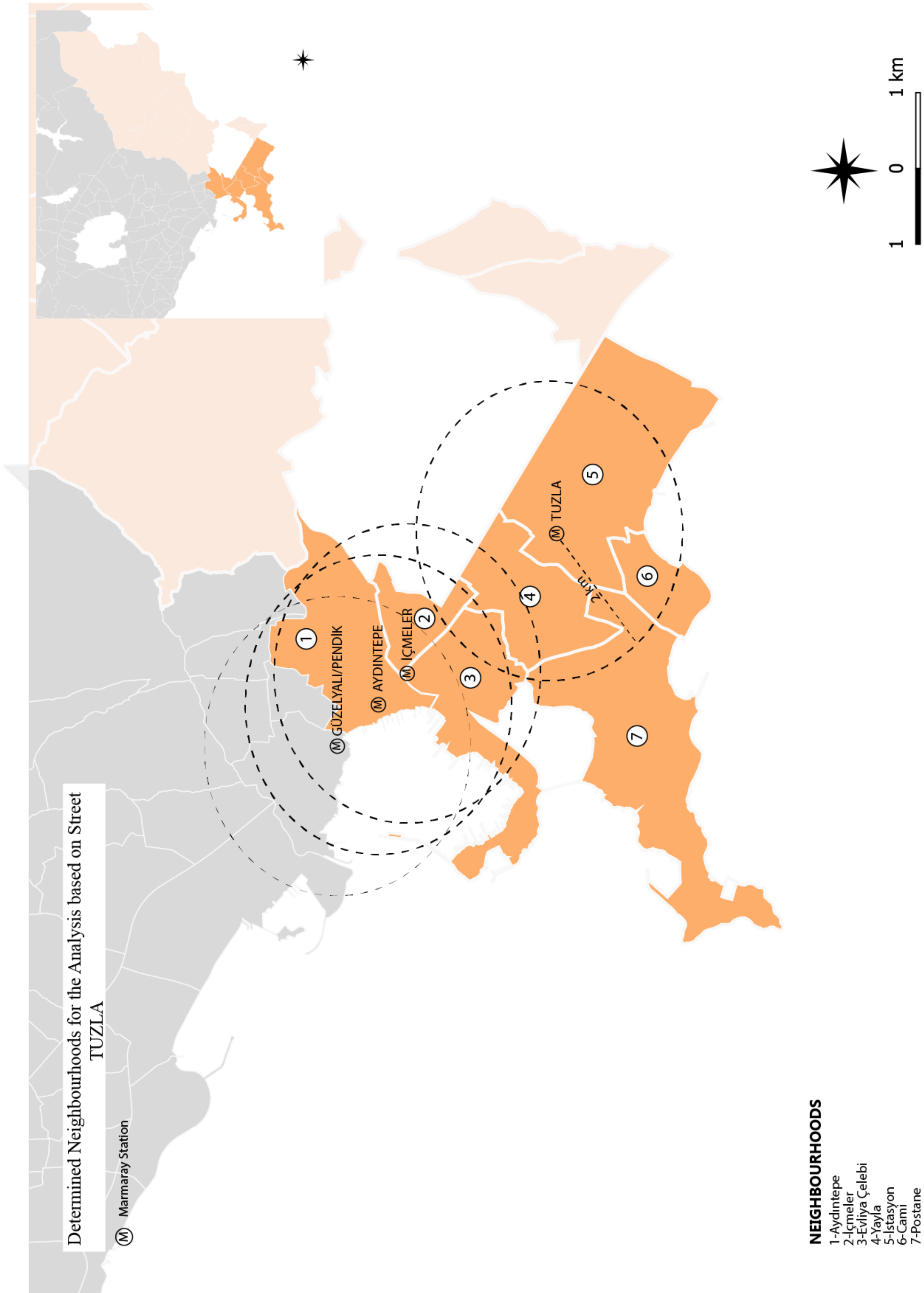

Figure 4.31. Scope area in Tuzla

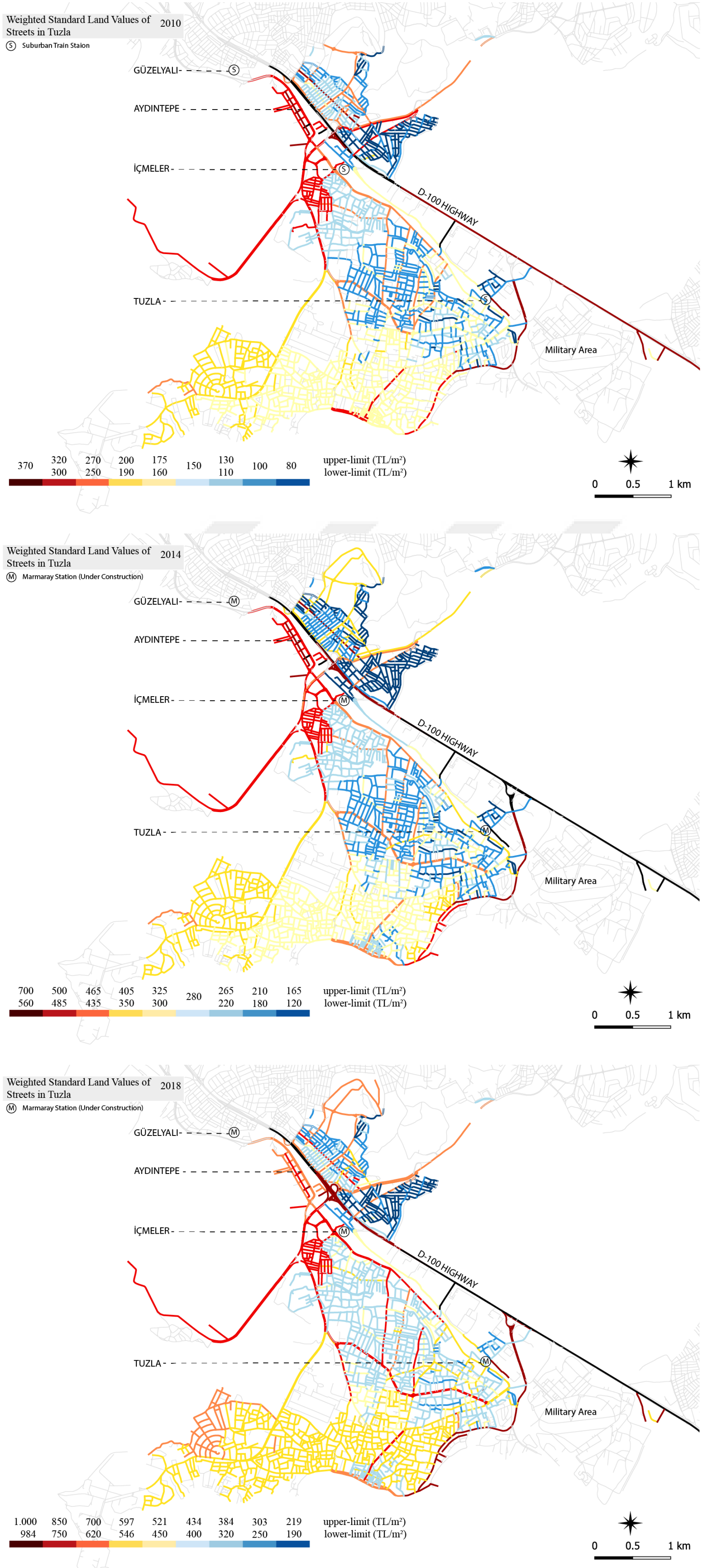

Figure 4.32. Neighbourhood-based maps of Tuzla (2010-2014-2018)

5. CONCLUSION

Infrastructure network transforms the urban space including the built environment and actors. This research sought to provide new ways to understand the impacts of urban infrastructure on urban space. The Marmaray Railway System was employed as a case study. Also, standard land values, which are determined every four years based on streets, were used as the database.

As a limitless city, Istanbul faces several problems on daily commuting. Historic suburban train systems of the European and Asian parts were the backbones of the linear city for decades. Further, it was a tool to re-determine the space and time matrices and to shape the urban macro form in the context of housing development. After the renewal process of the train lines and the implementation of an undersea tunnel in order to connect the separated lines, time and space matrices were re-constructed by the Marmaray. Therefore, this research aimed to answer some questions given in the introduction part.

One question was about the spatial impacts of the urban infrastructure. As one can see in the literature review and the history of urban development of Istanbul, the infrastructure comes to mean more than technical issues. Rather, they constitute the very nature of cities, even though most of them exist in invisible forms (Graham and Marvin, 2001). In the case of Istanbul, the urban macro form was shaped very much through the implementation of infrastructure projects. In this context, urban transportation is one of the key factors that created the linear urban form in Istanbul. Firstly, the sea transportation and later suburban railway systems encouraged the city to be shaped. Thus, de-concentration of the urban centre was observed in the following years of the first suburban train systems. Furthermore, according to the historical records of some articles, implementation of the train systems stimulated the land values and so they were pushed up.

The research handled the subject of the suburban railway systems in Istanbul. Therefore, a Marmaray based research was required. The Marmaray Railway System is an infrastructure project that connects the suburban train systems separated by a geographical threshold called the Istanbul Strait. To answer the question about the relation between the Marmaray and the property values, it was necessary to build a methodology to synthesise the large datasets. So, after the stratifications, cartographic data were visualised on the GIS, and it was produced some maps in several scales. Applied methodology through relational stratification and the maps gave the answers for one of the questions about the way of research.

Produced maps provided significant insights into the research questions. It was expected to observe the change of equilibrium distributions on the places where the Marmaray system passes. However, used data contained the year cases of 2010, 2014 and 2018. The first phase of the Marmaray was opened in 2013, whereas the old suburban train systems were closed in 2013 and the second phase of the Marmaray was put in service in 2019. By analysing the 2018 data, it was also expected to see the potential value increases around the stations where were under construction as the second phase of the project. On the one hand, the results showed that standard land values around the mentioned stations increased. On the other hand, other areas that were analysed also increased at different rates. Thus, the stratifications of streets did not show the major changes over the case areas.

Further, this research provided some unpredicted findings. Some impacts due to the absence of the suburban train systems were observed. These impacts were able to be read when the maps of 2010 and 2014 were analysed. The absence of the system caused a change of distribution balances of stratified cases more than the existence of the system. It should not be forgotten that the analysed areas are not ideal or isolated places like von Thünen's models. Property values are sensitive not only to suburban train services. Rather, they are affected by multi-layered factors. Therefore, the distribution balance of the values is not affected only by the Marmaray. On the contrary, other external factors affect the built environment quite a lot such as urban transformation, migration, controlled clusters/areas, and gentrification processes. In this context, implementation of the new urban transportation systems, rapid urban transformation process and policies change the spatial priorities. Therefore, some unpredicted results were offered.

Moreover, the opening of the first phase of the Marmaray changed the distribution balances of street values in minor scales. Especially, Fatih (Appendix B.4) and Üsküdar (Appendix B.5) displayed these changes after the opening of the first phase. Around the stations, it could be seen "hotspots" that were created by the gravity force of the stations. As it monitors on the maps, it was apparent that street-based maps provided more detailed results than the neighbourhood-based maps. Thus, major changes were monitored on the street-based maps more than neighbourhood-based maps. Besides, it should be kept in mind that some districts, especially Fatih, are the saturated districts in terms of property values because of its historical development. Thus, these districts are not expected to show major changes and not much uplift could be created further by the Marmaray.

According to the produced maps, stations acted as a gravity centre as quoted in the literature view section. They gradually affected the surrounded area of it. Therefore, the streets where were close to the stations represented relatively higher-valued classes whereas those where were far from the stations represented relatively lower-valued classes. However, the streets that were found relatively far from the stations did not offer major changes which means the distribution balances of street values did not change a lot. As mentioned above, other external factors could be a key factor in this case.

The last question pointed out the profiles of neighbourhood residents and change of them through the implementation of the Marmaray. It should not be forgotten that, the standard land value does not offer detailed information. Rather, it provides something in overall scale. Since it is evaluated based on streets, it also displays the social profiles of the streets. Therefore, in this research, standard land values were attributed as an indicator of spatial profiles. But then, the results did not reveal major changes in terms of stratification of values. Thus, it cannot be interpreted that the residents' profiles were affected since the visualised maps did not offer any spectacular change due to the construction of the Marmaray. Exclusively, the profiles of residents, where lived in the streets that were called "hotspots" or the neighbourhoods that showed some sharp changes, might be changed because of changed stratifications.

In general, this research found out that transition from existence of the suburban train system to absence of the system made an impact dramatically more than the impact of the opening of the first phase of the Marmaray. So, analysed dataset showed that the places that were cut off the suburban train system in 2013 tent to show a decrease in terms of their standard land values. Also, there were some limitations in the study. For instance, used data were instant. Therefore, findings showed the moment when the data were recorded. Secondly, standard land values might be valuated arbitrary by the committees. Some places (i.e. Kınalıada) represent the highest standard land values whereas they should not do and vice versa. So, the data might not be the most reliable ones.

Finally, further researches are needed to understand the implications of infrastructure projects, the Marmara particularly. Next dataset of standard land values will be evaluated in 2022. For this reason, a research that contains the dataset of 2022 can provide some detailed insights since the impacts of the second phase of the Marmaray will be seen through the analysis of this dataset. On the other hand, it is clearly predicted that there will be major changes in urban dynamics or even effects of a pandemic like COVID-19 in Istanbul by 2022. So, the impacts of the Marmaray might not be observed in the long run. Therefore, researches that will be done through the dataset of 2022 will require to employ a broader perspective so to distinguish the multi-layered external effects. This research can also be utilised as a template for the further studies where the urban data are the focal point. Further, if the current data are developed, it will also allow for the exploratory works.

In conclusion, this research aimed to show the impacts of urban infrastructure. It was distinct from the studies given in the literature in terms of its methodology. This methodology can be applied and developed for the further studies on the stratification of complex datasets. Future researches are needed to seek other external relationships to get the broader results.

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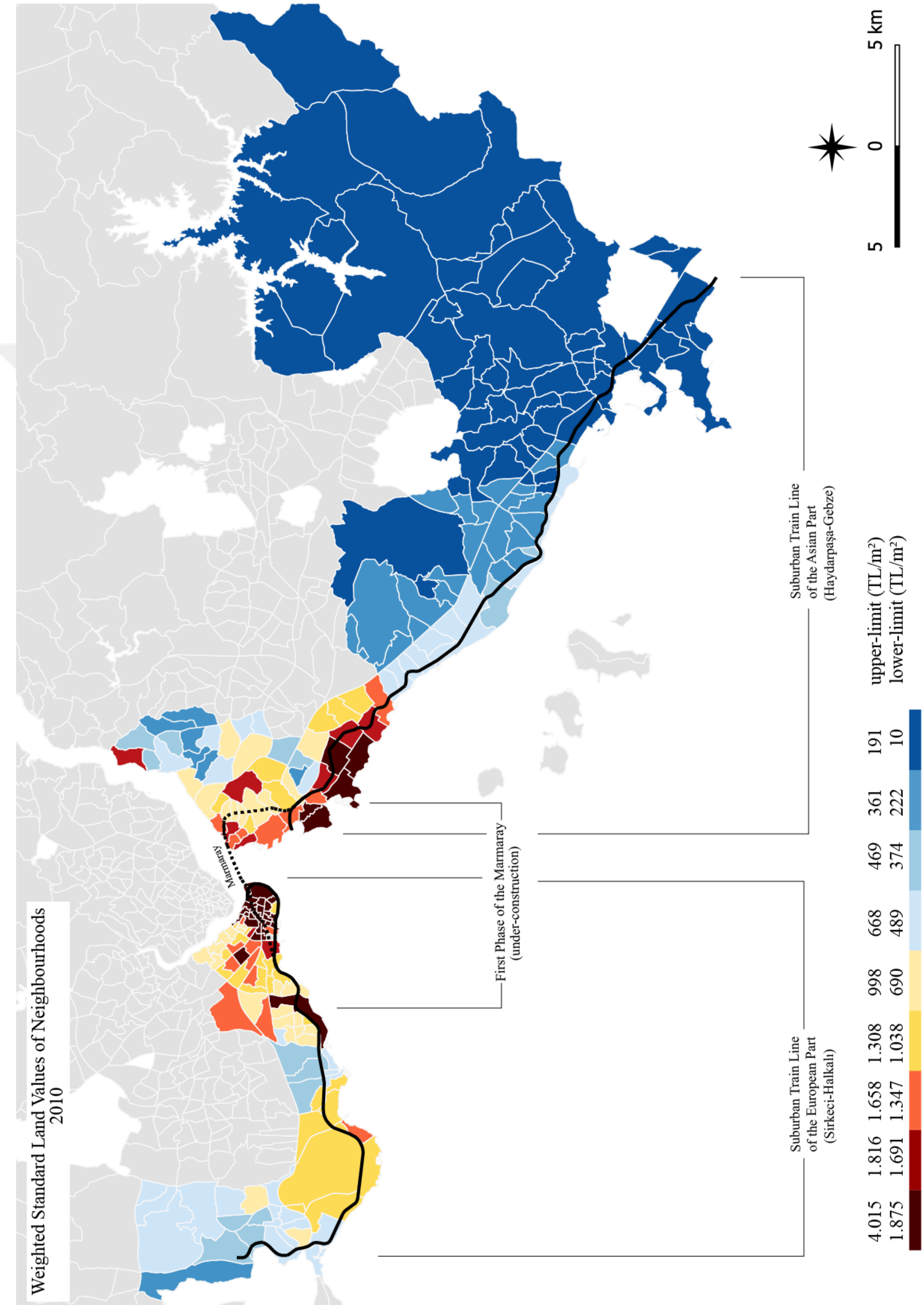
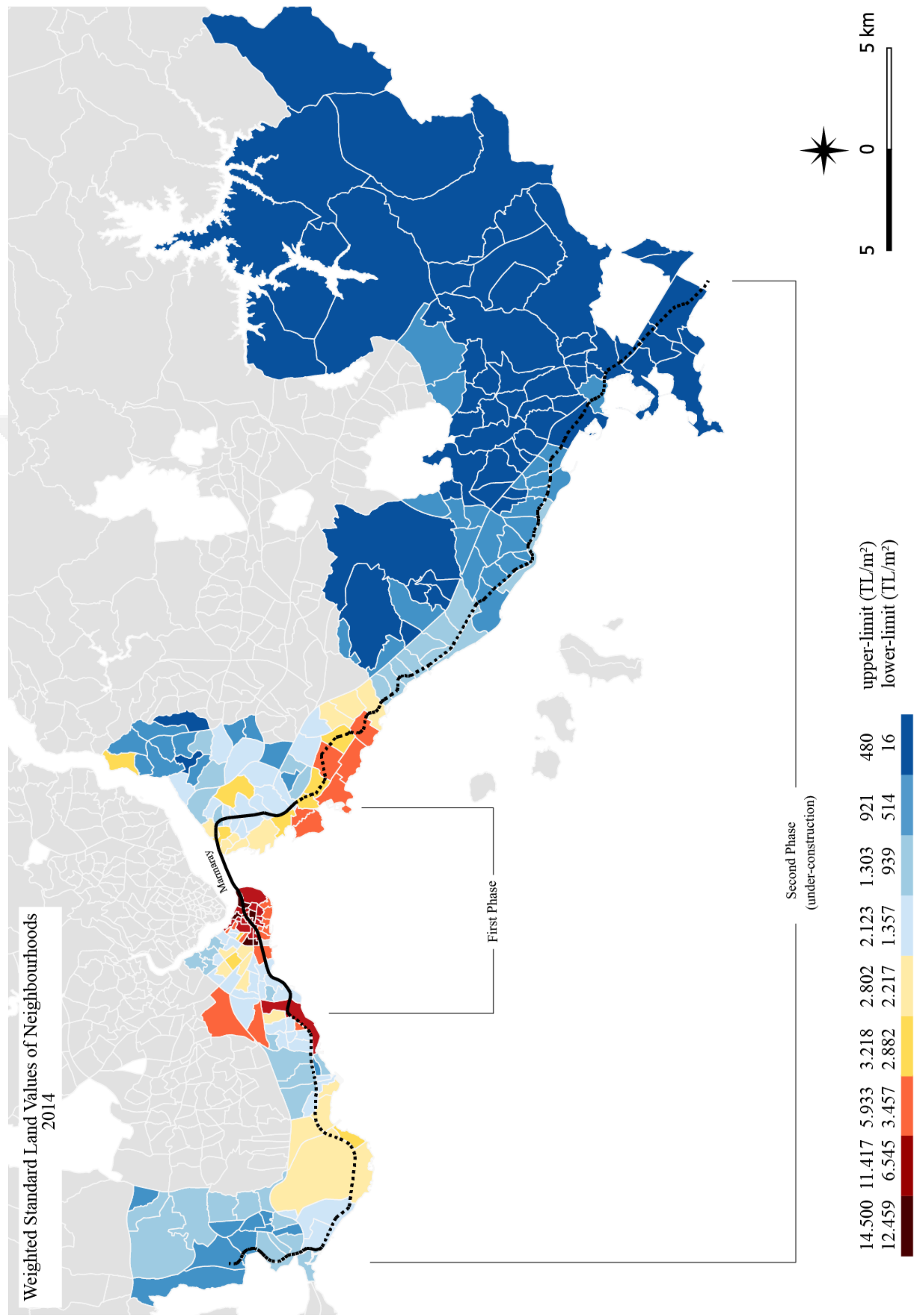
APPENDIX

APPENDIX A: General View of Istanbul

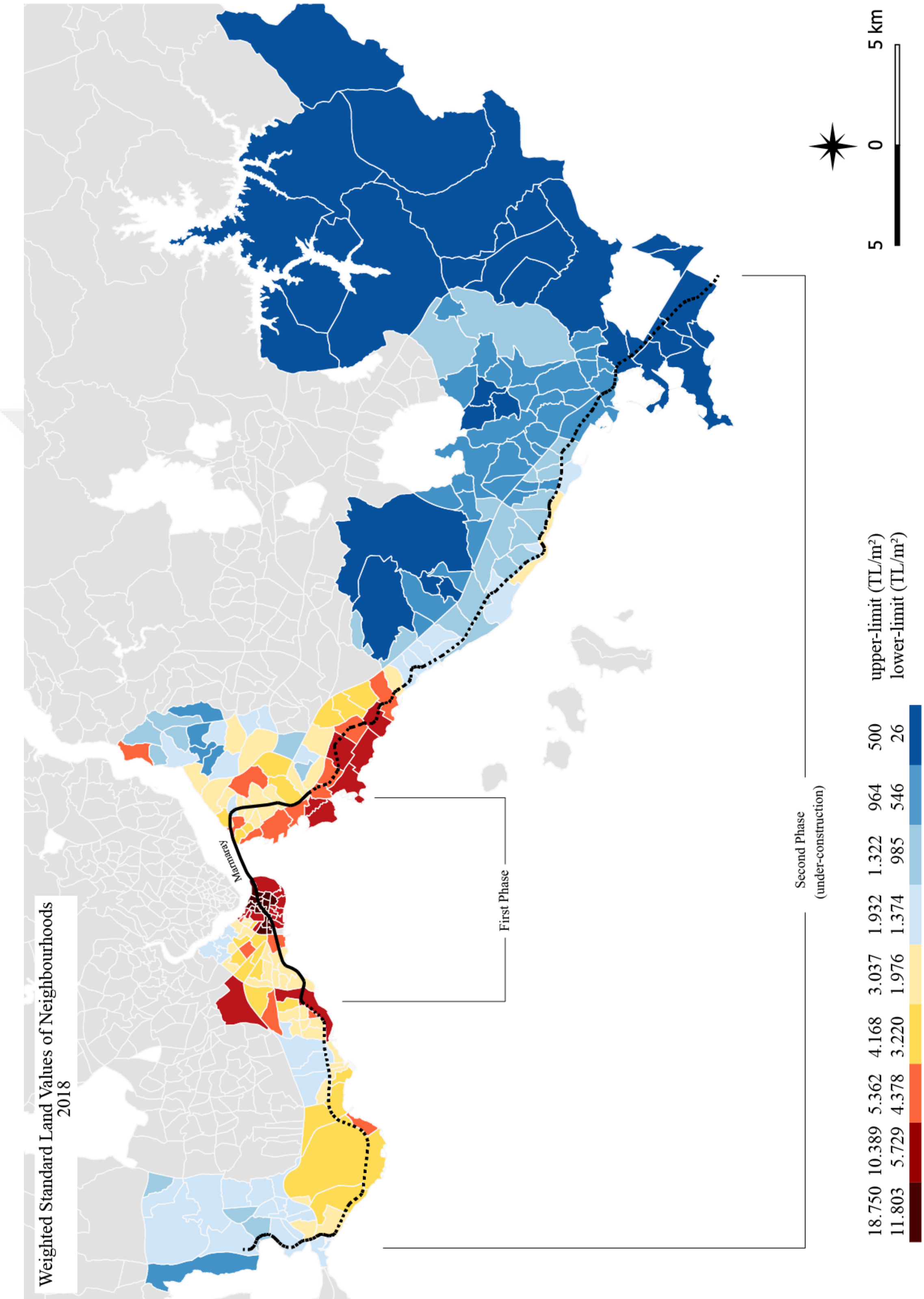
A.1 Weighted Average Standard Land Values of Neighbourhoods in Istanbul – 2010



A.2 Weighted Average Standard Land Values of Neighbourhoods in Istanbul – 2014



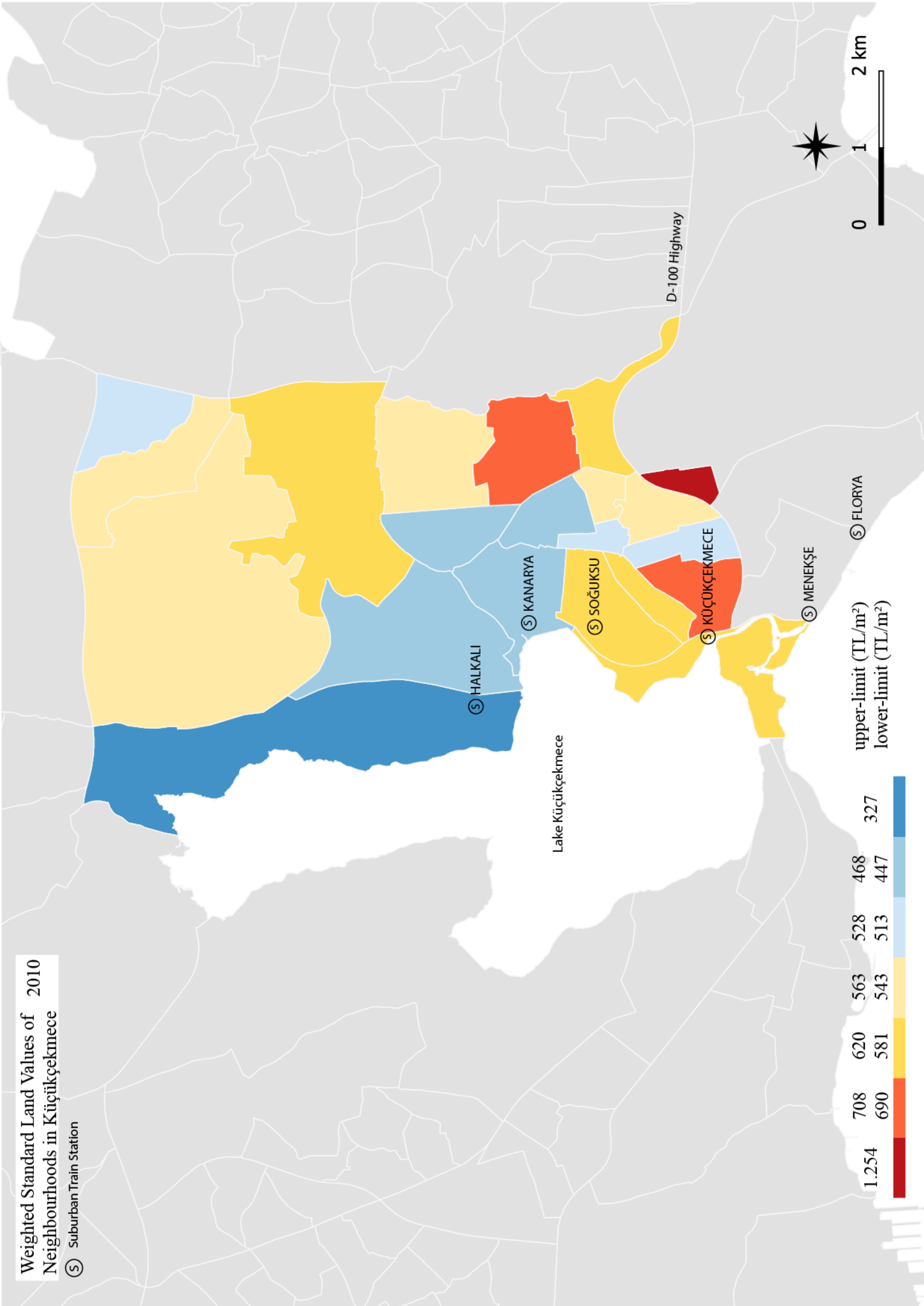
A.3 Weighted Average Standard Land Values of Neighbourhoods in Istanbul - 2018



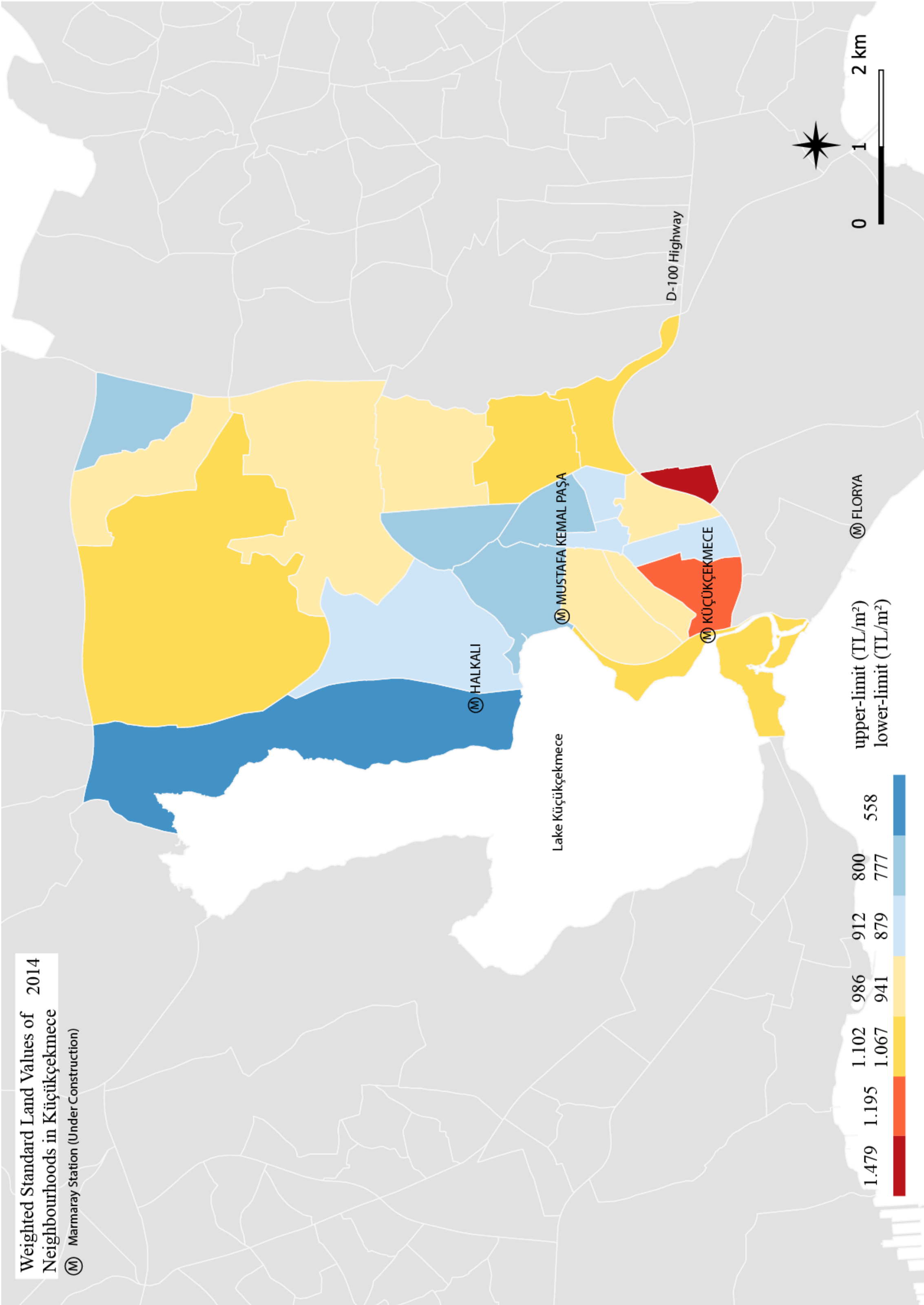
APPENDIX B : Analysing the Districts in Istanbul

B.1 KÜÇÜKÇEKMECE

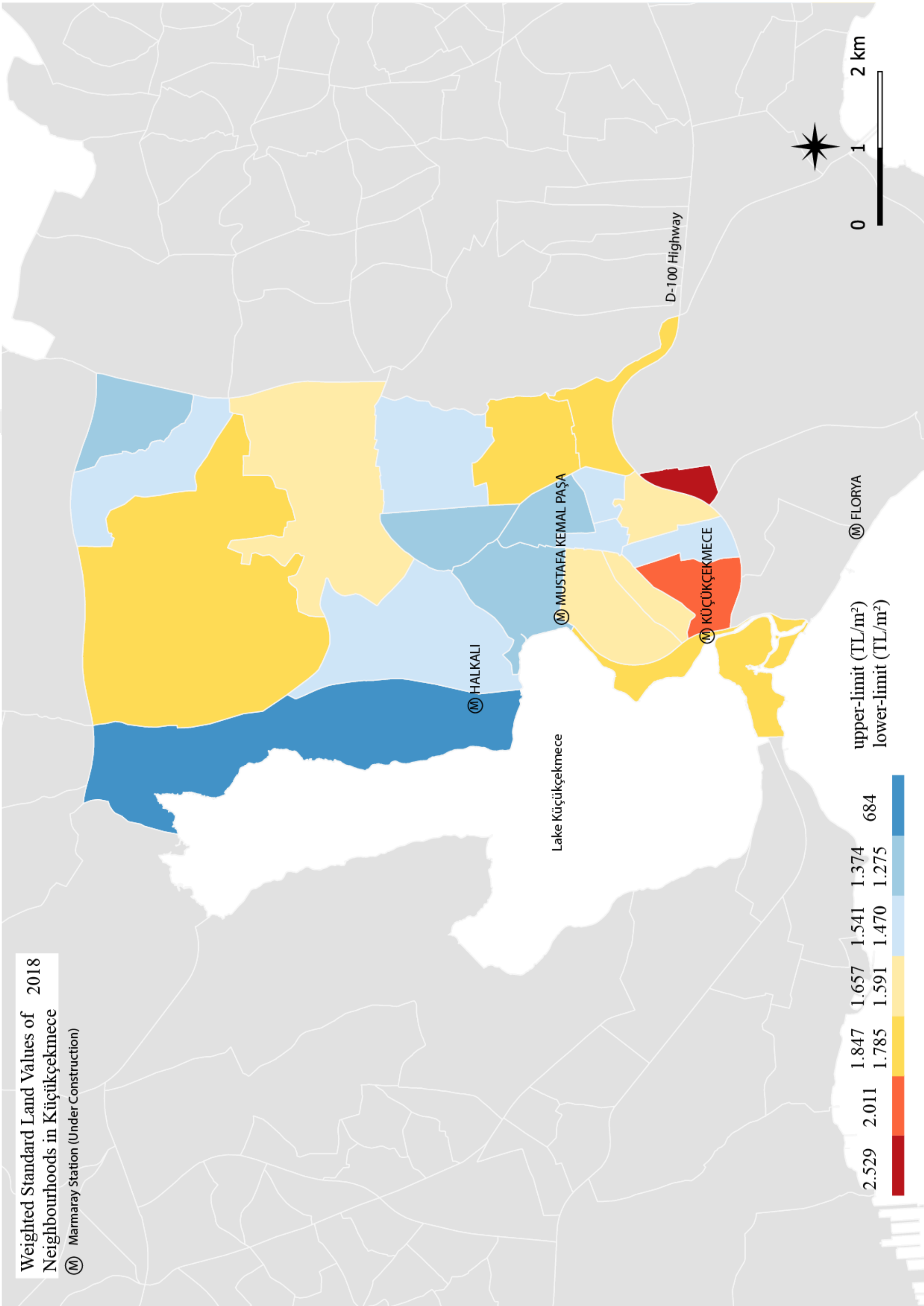
B.1.1.1 Weighted Average Standard Land Values of Neighbourhoods – 2010



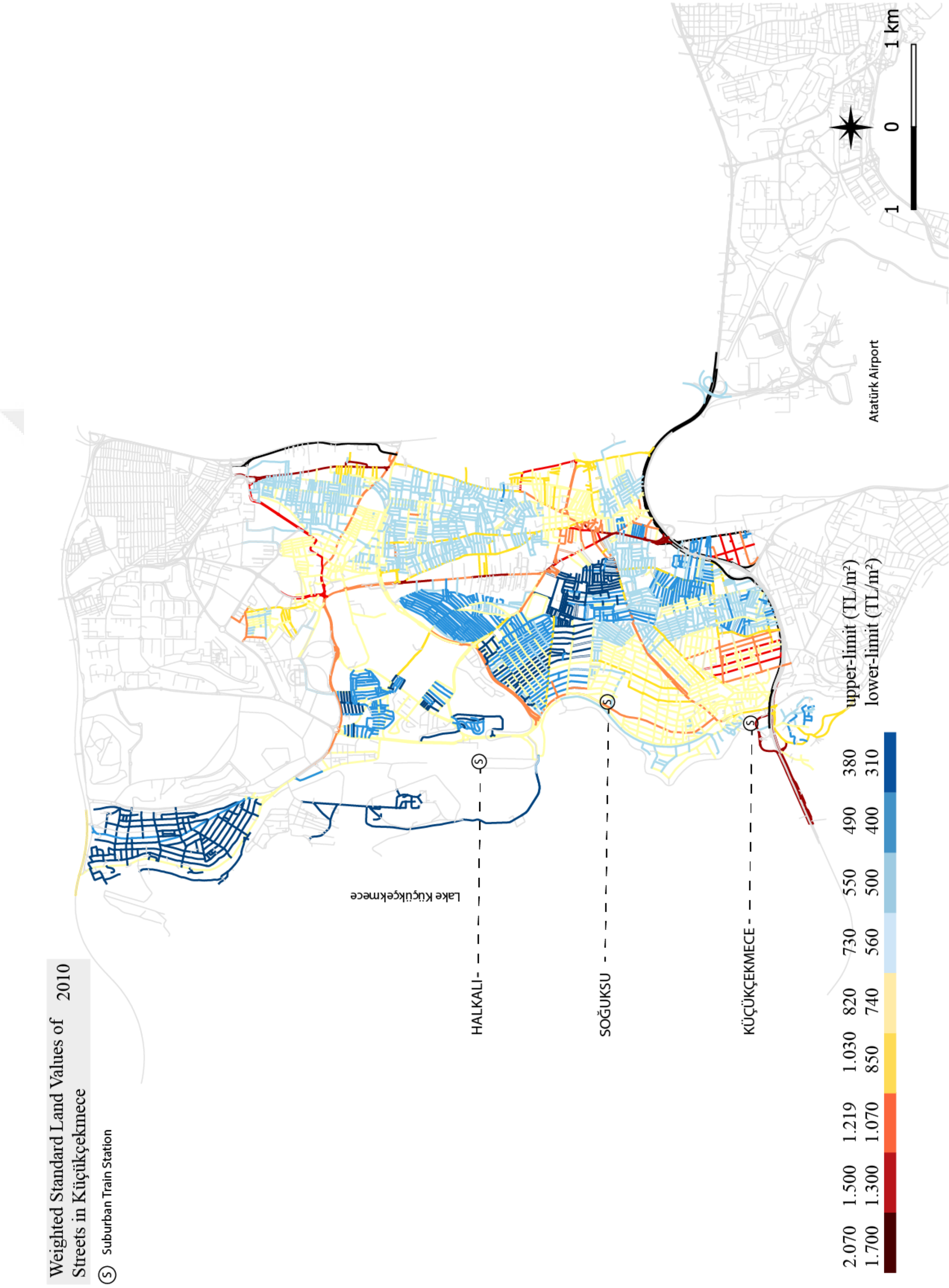
B.1.1.2 Weighted Average Standard Land Values of Neighbourhoods – 2014



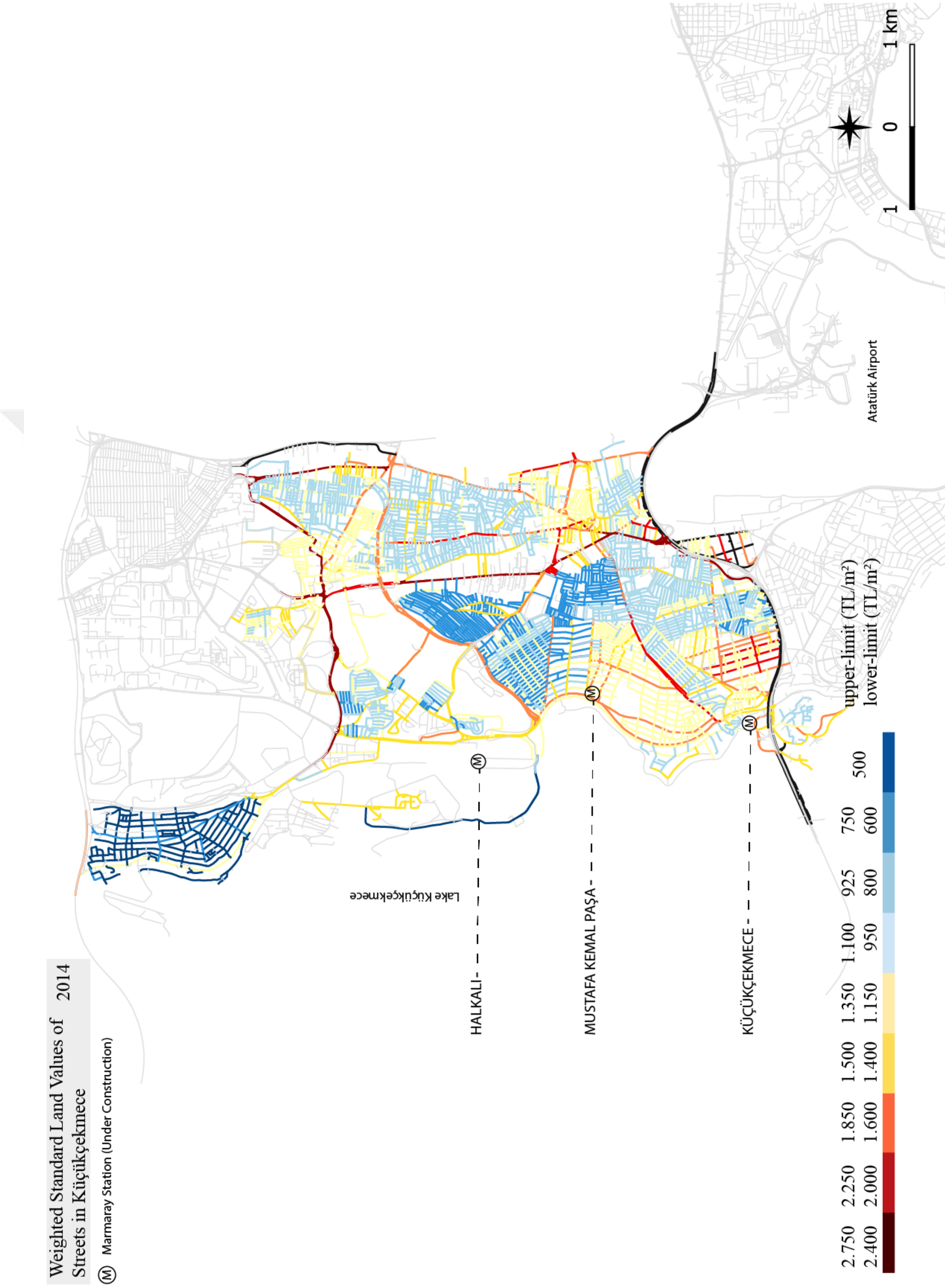
B.1.1.3 Weighted Average Standard Land Values of Neighbourhoods – 2018



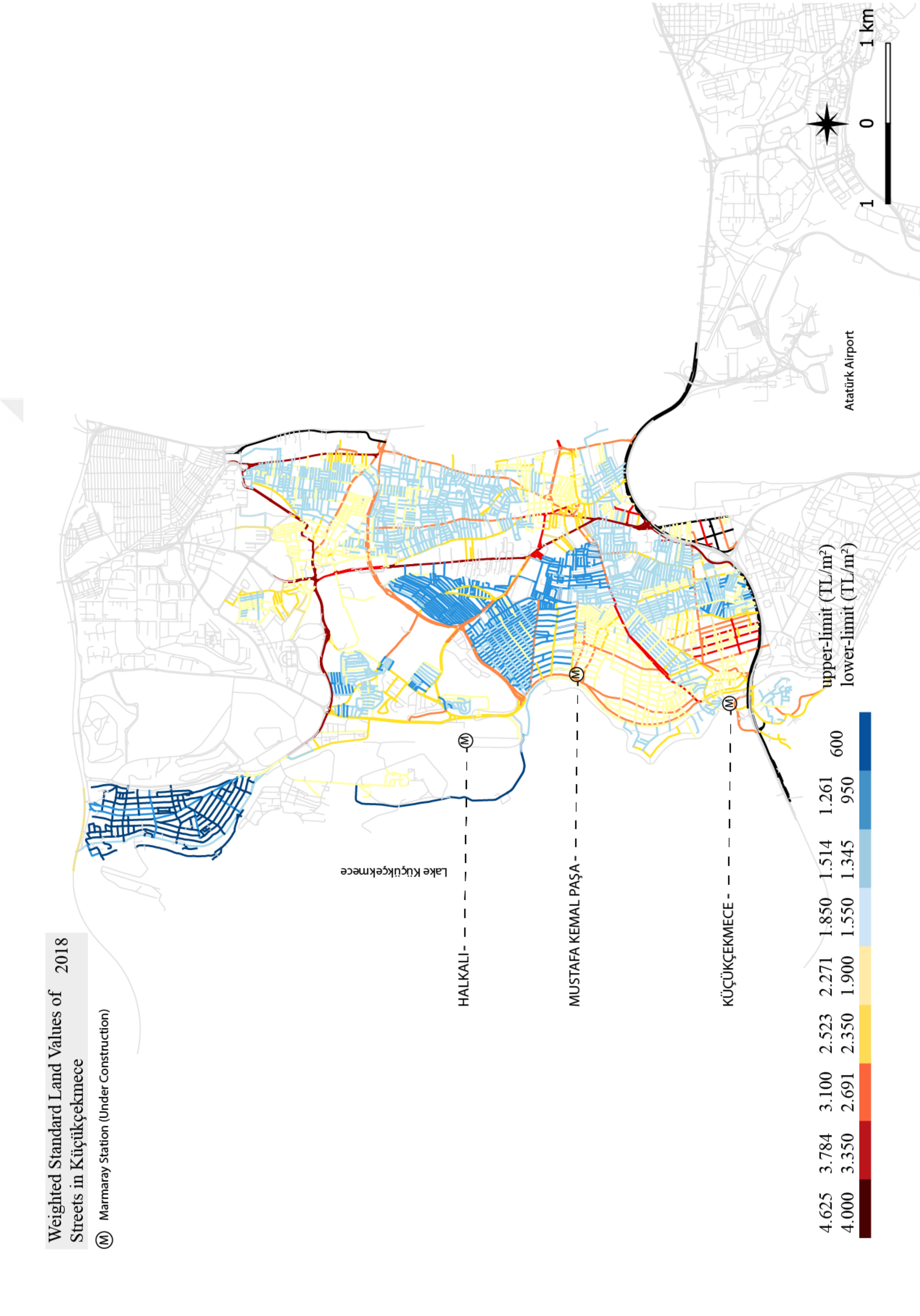
B.1.2.1 Weighted Standard Land Values of Streets – 2010



B.1.2.2 Weighted Standard Land Values of Streets – 2014

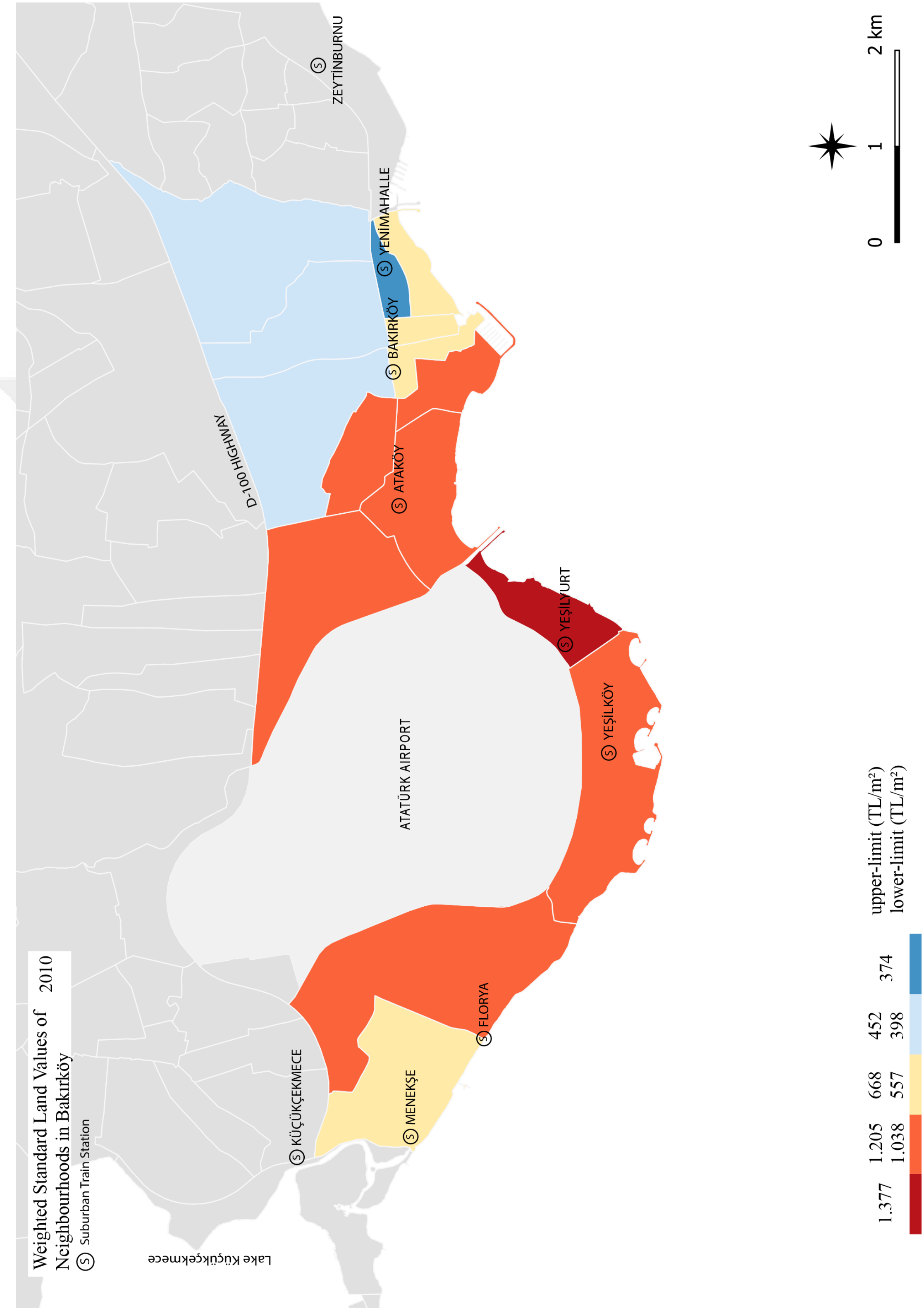


B.1.2.3 Weighted Standard Land Values of Streets – 2018

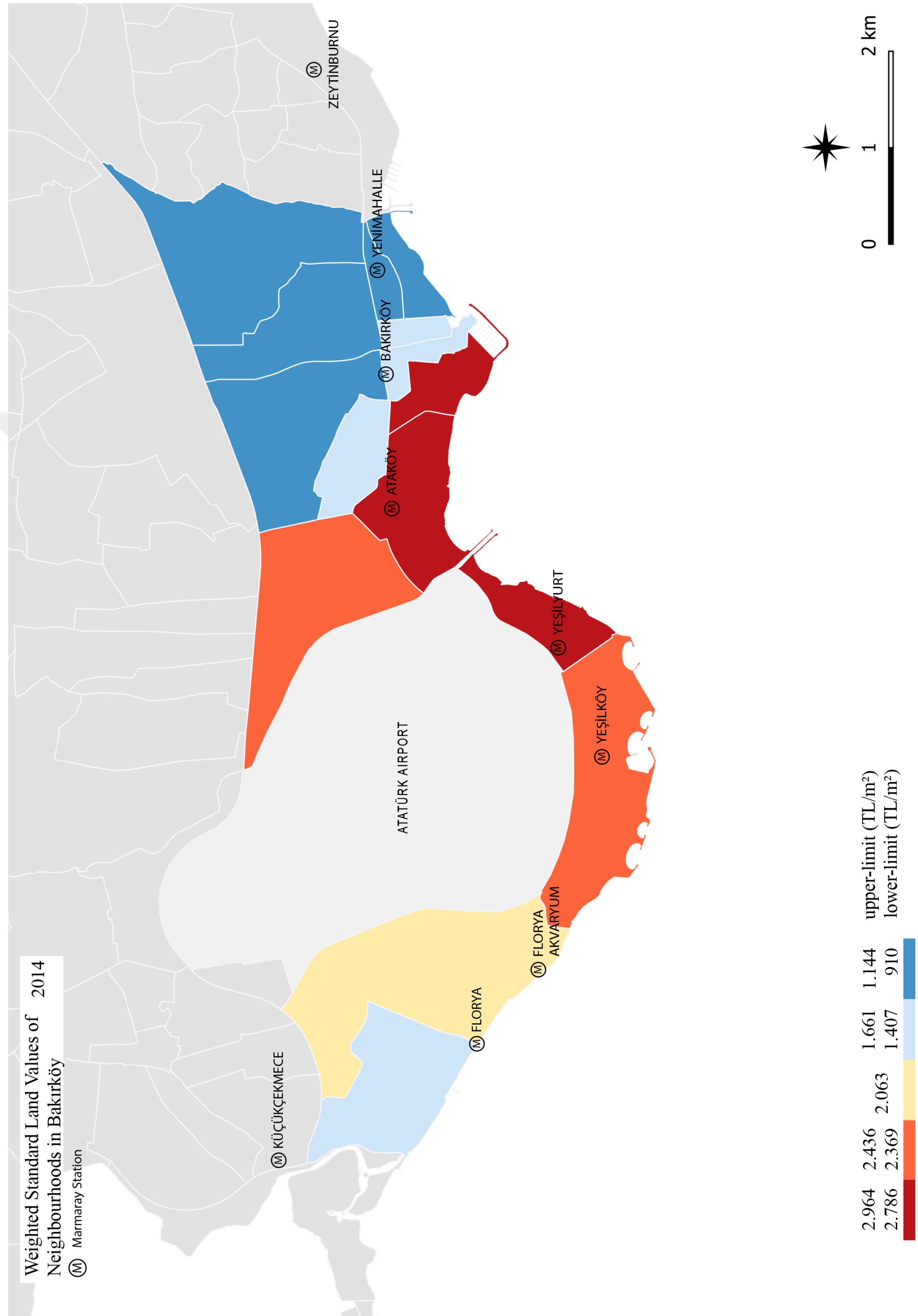


B.2 BAKIRKÖY

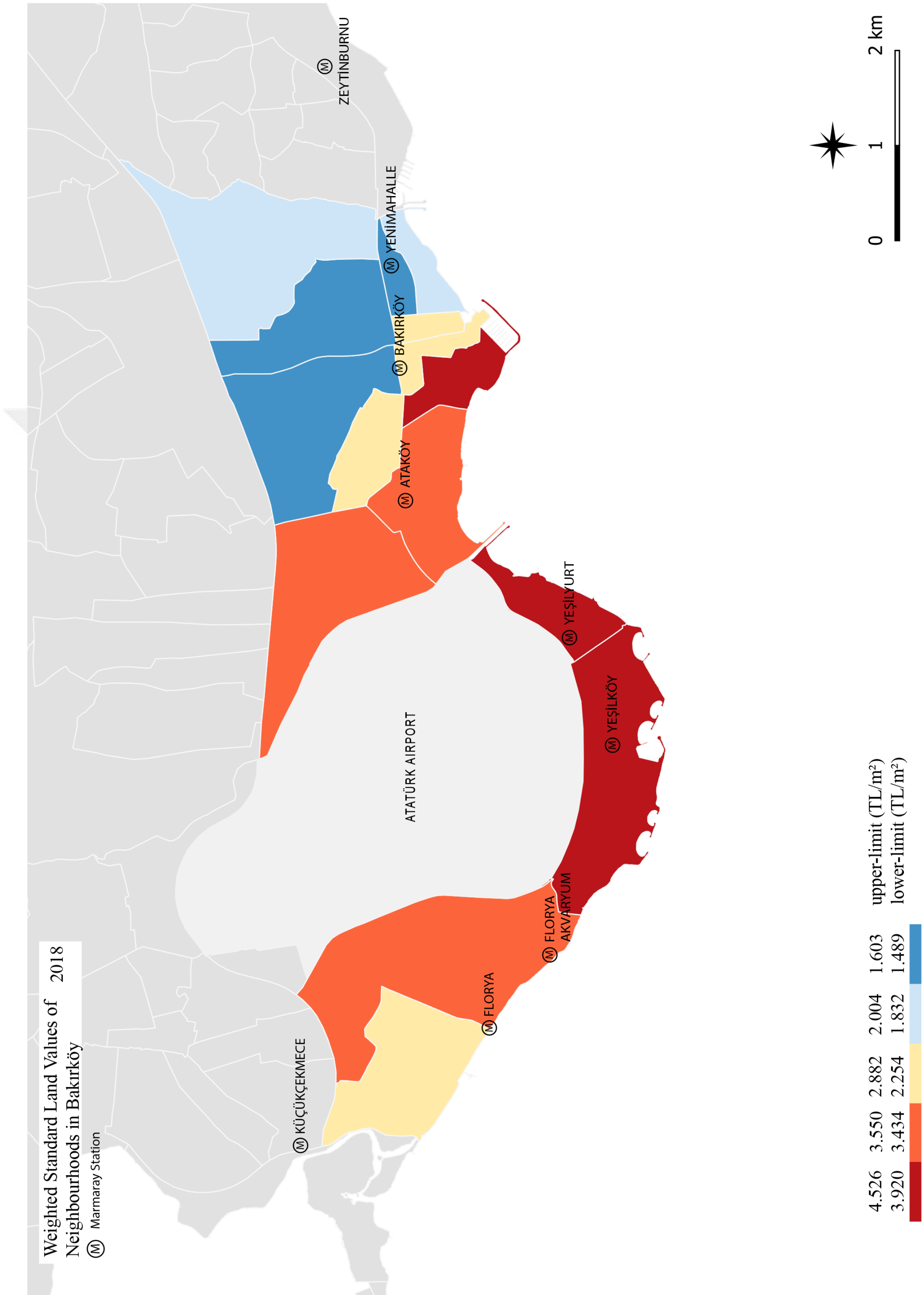
B.2.1.1 Weighted Average Standard Land Values of Neighbourhoods – 2010



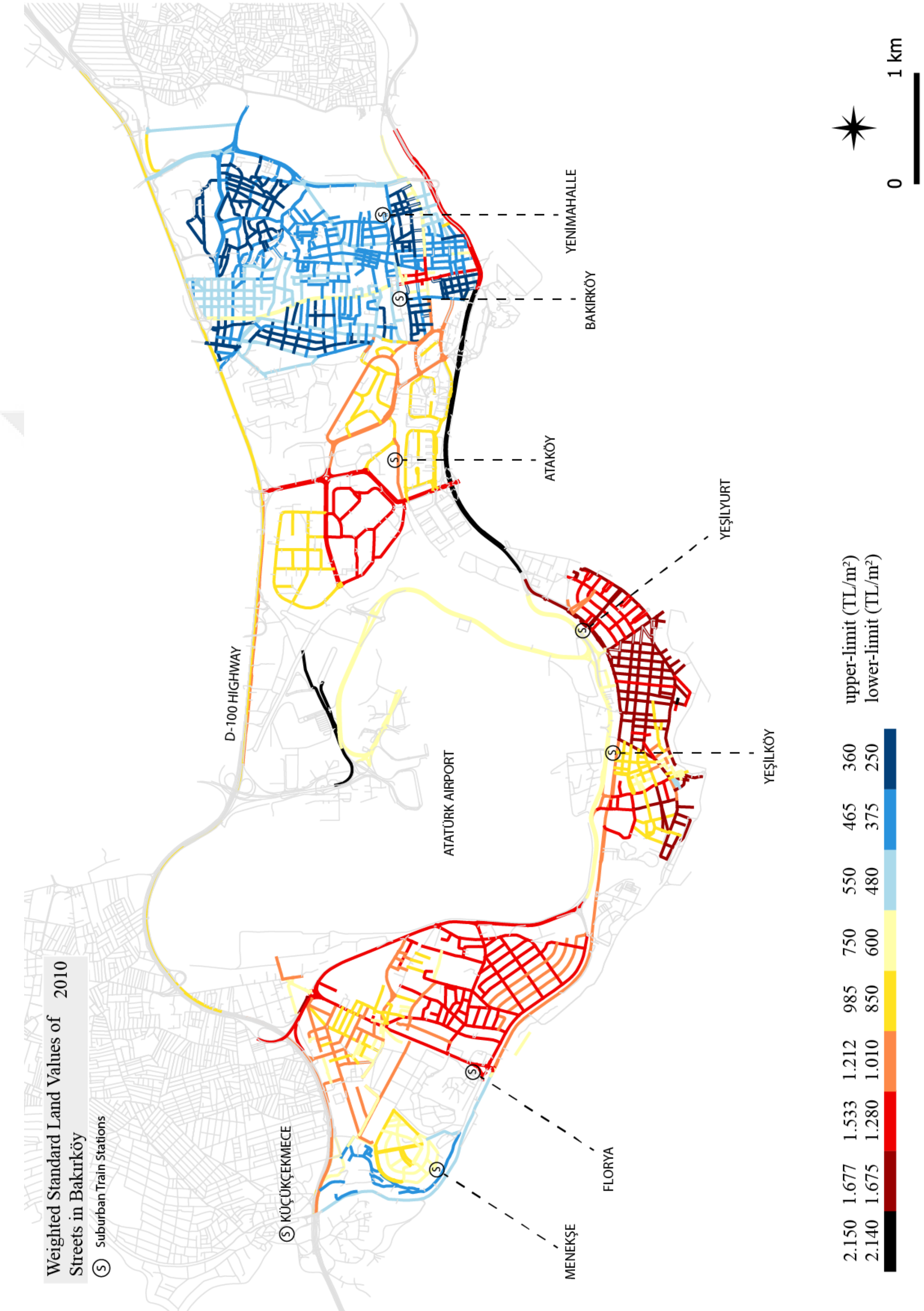
B.2.1.2 Weighted Average Standard Land Values of Neighbourhoods – 2014



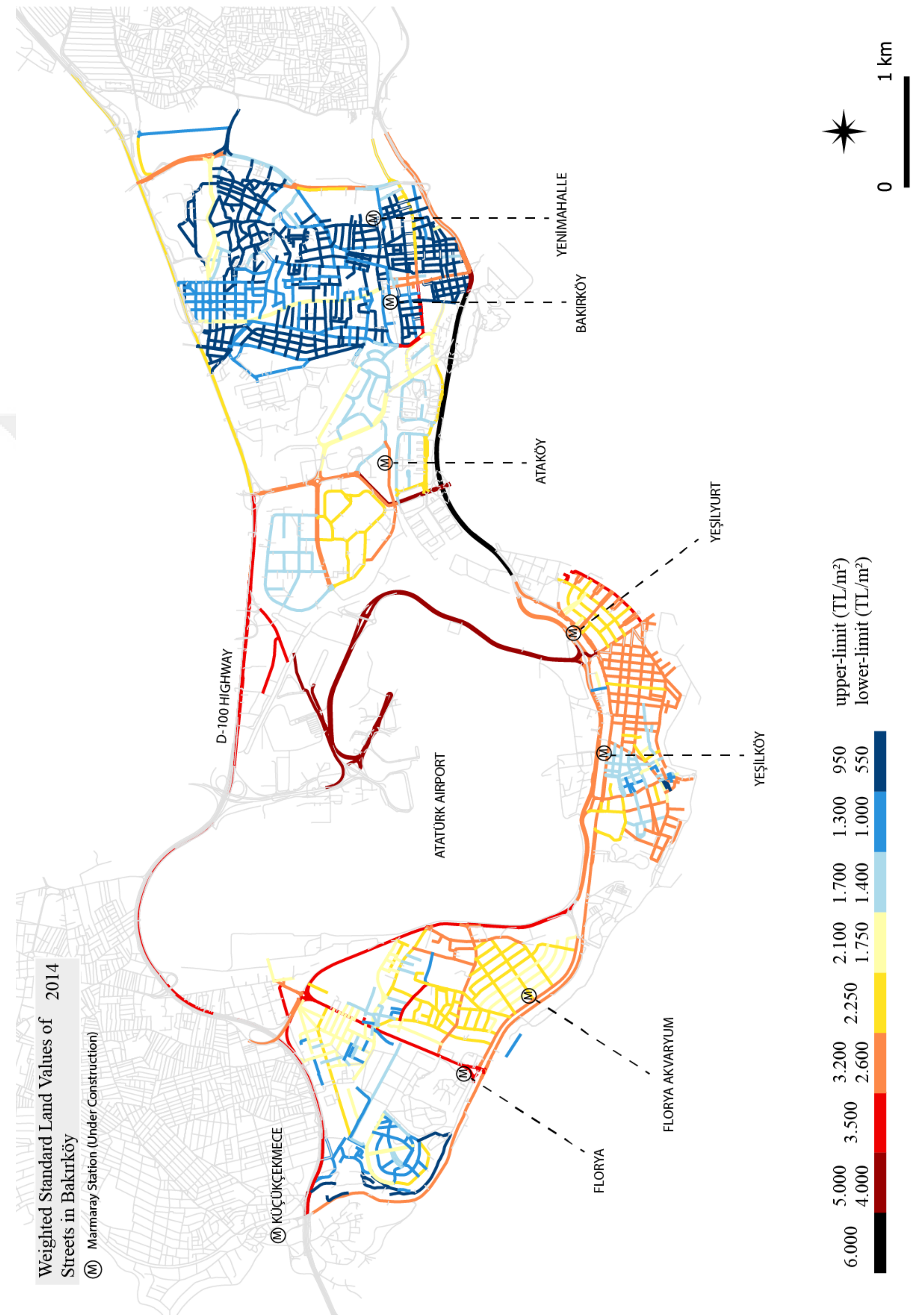
B.2.1.3 Weighted Average Standard Land Values of Neighbourhoods – 2018



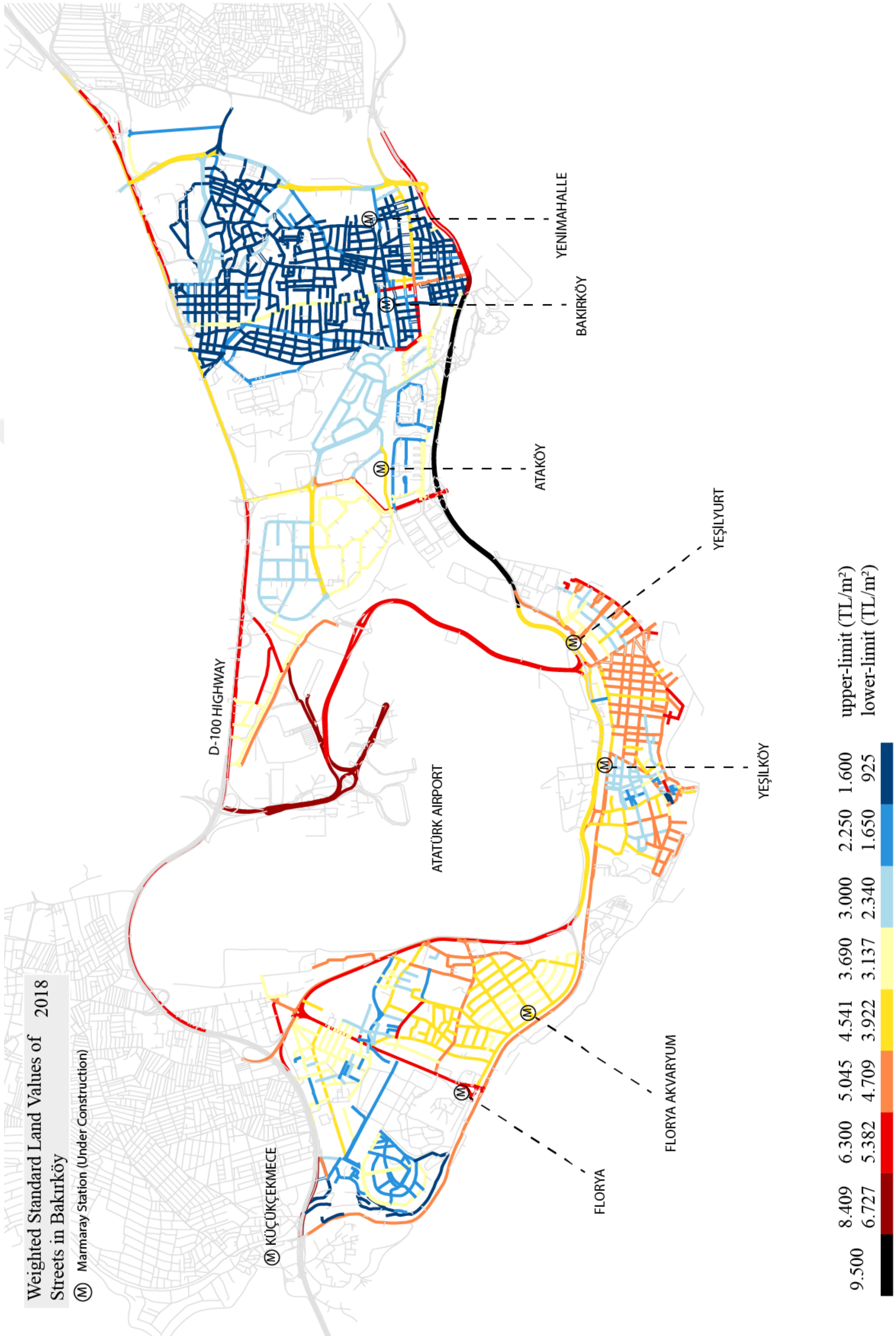
B.2.2.1 Weighted Standard Land Values of Streets – 2010



B.2.2.2 Weighted Standard Land Values of Streets – 2014

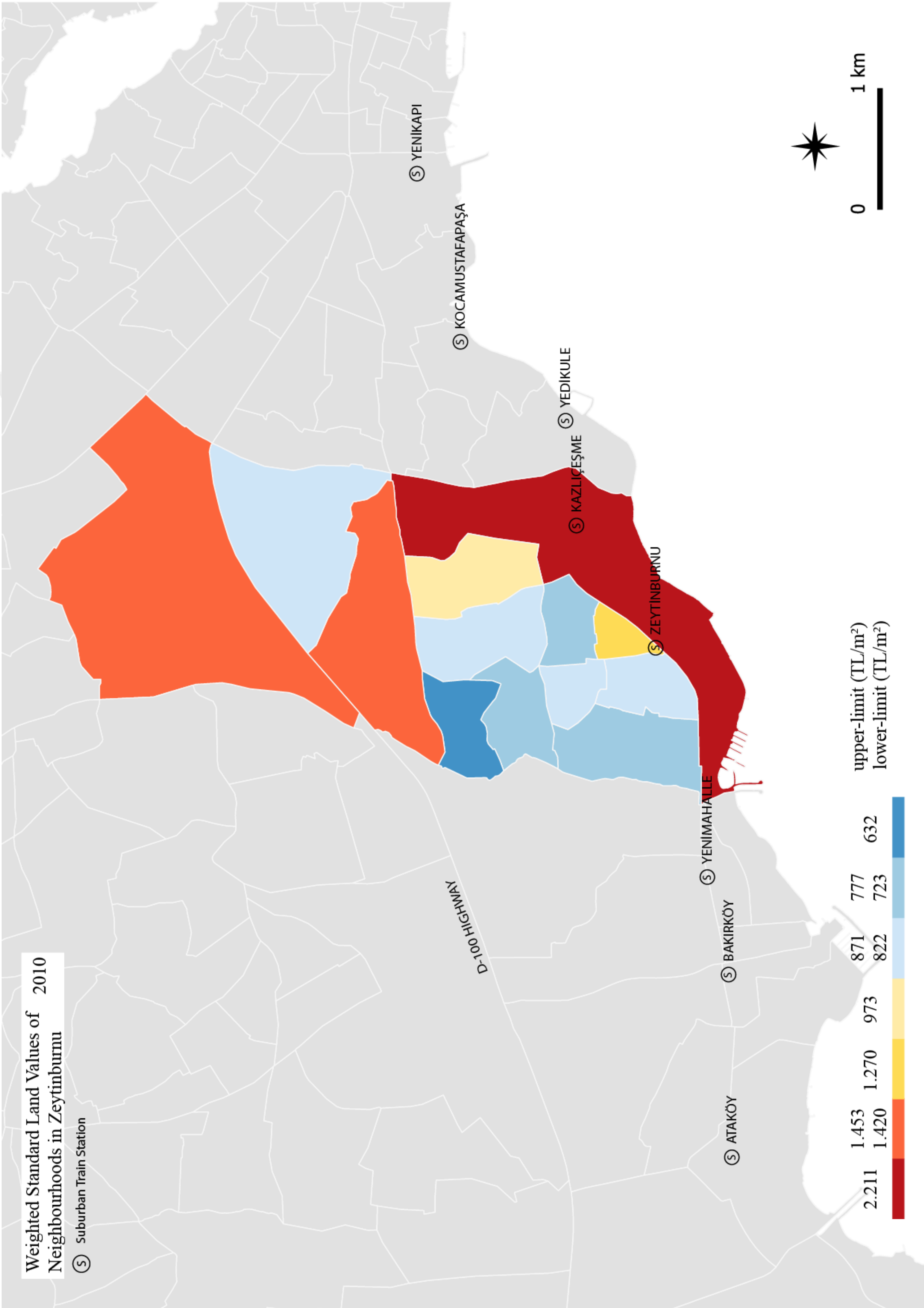


B.2.2.3 Weighted Standard Land Values of Streets – 2018

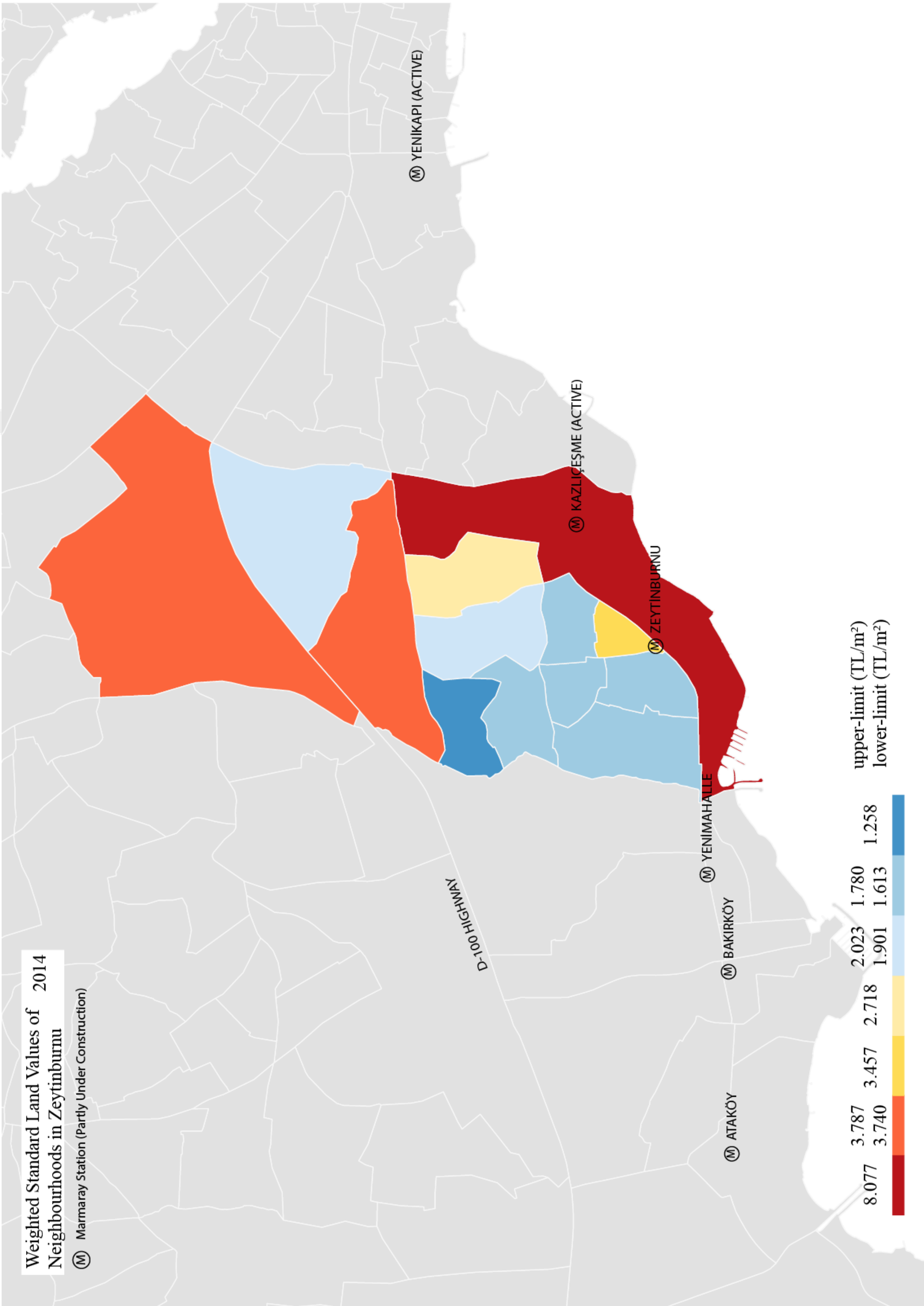


B.3 ZEYTİNBURNU

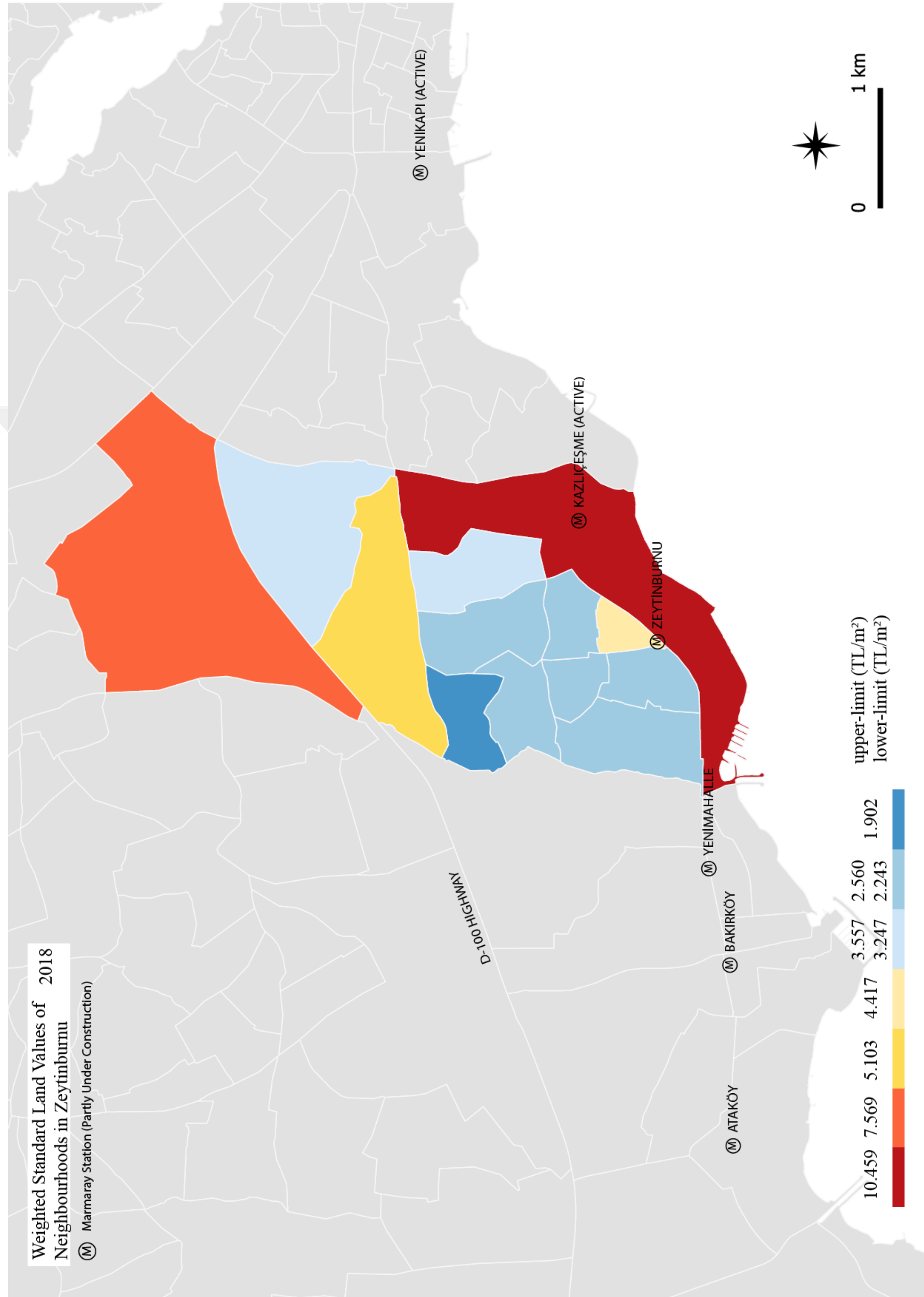
B.3.1.1 Weighted Average Standard Land Values of Neighbourhoods – 2010



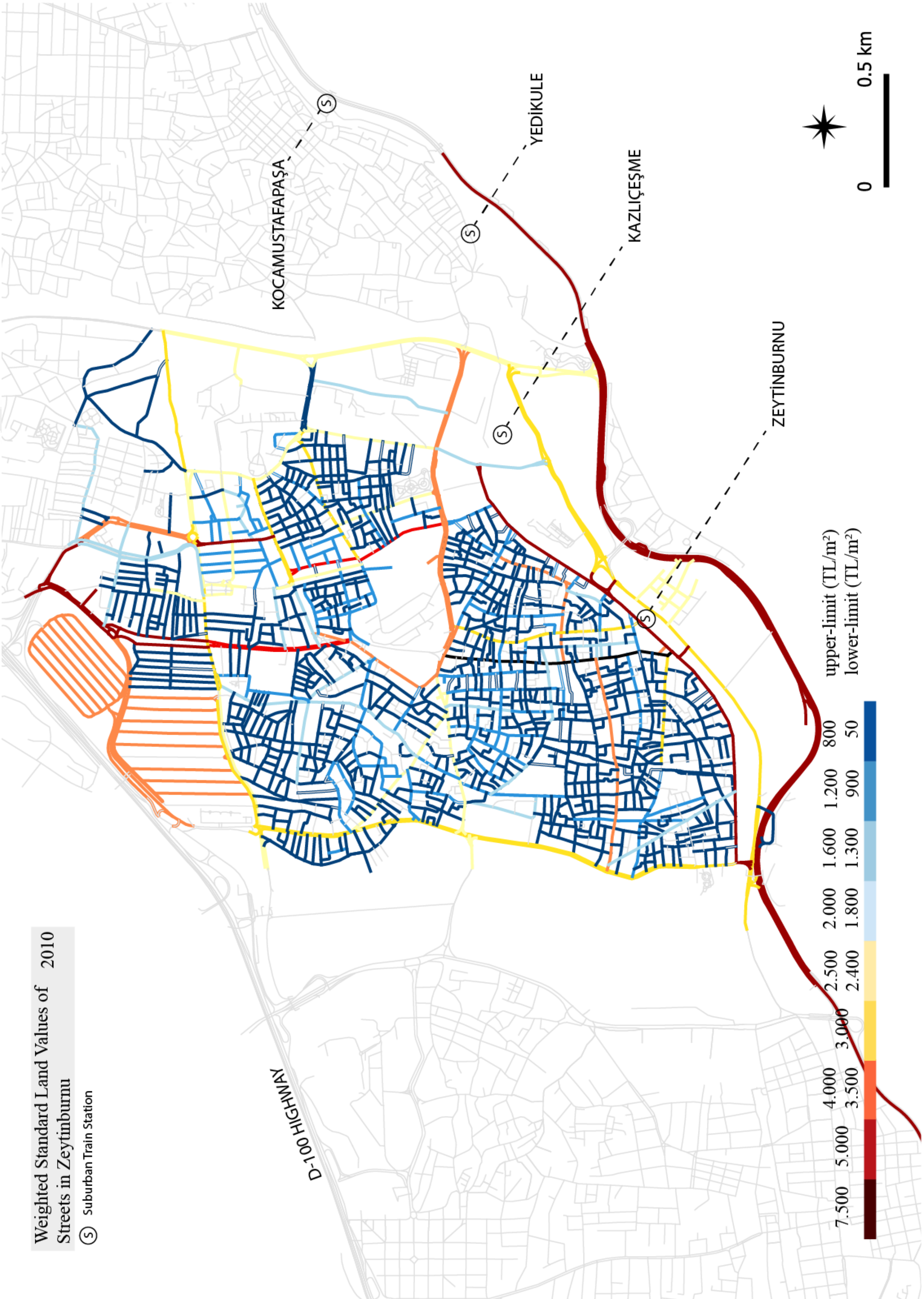
B.3.1.2 Weighted Average Standard Land Values of Neighbourhoods – 2014



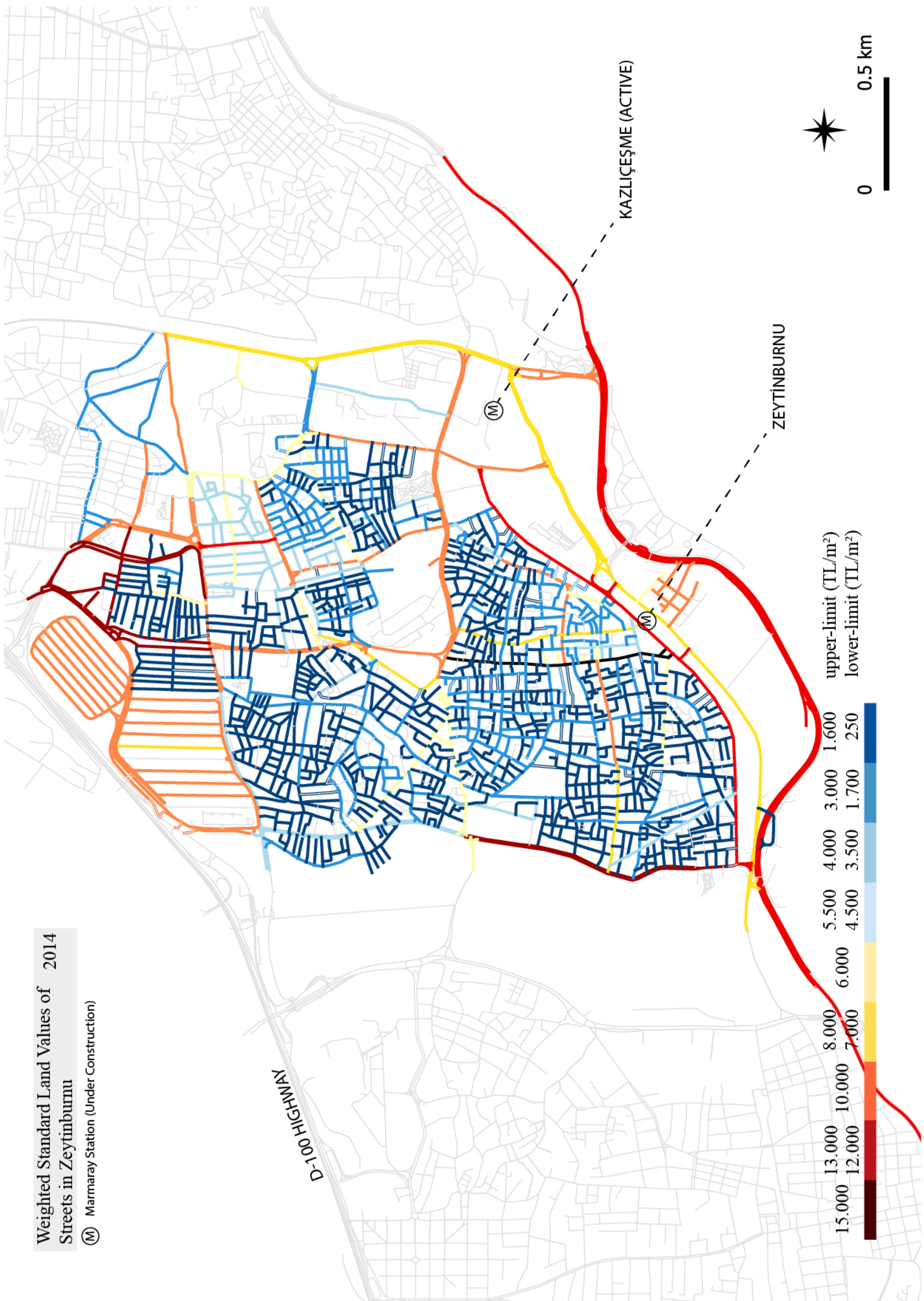
B.3.1.3 Weighted Average Standard Land Values of Neighbourhoods – 2018



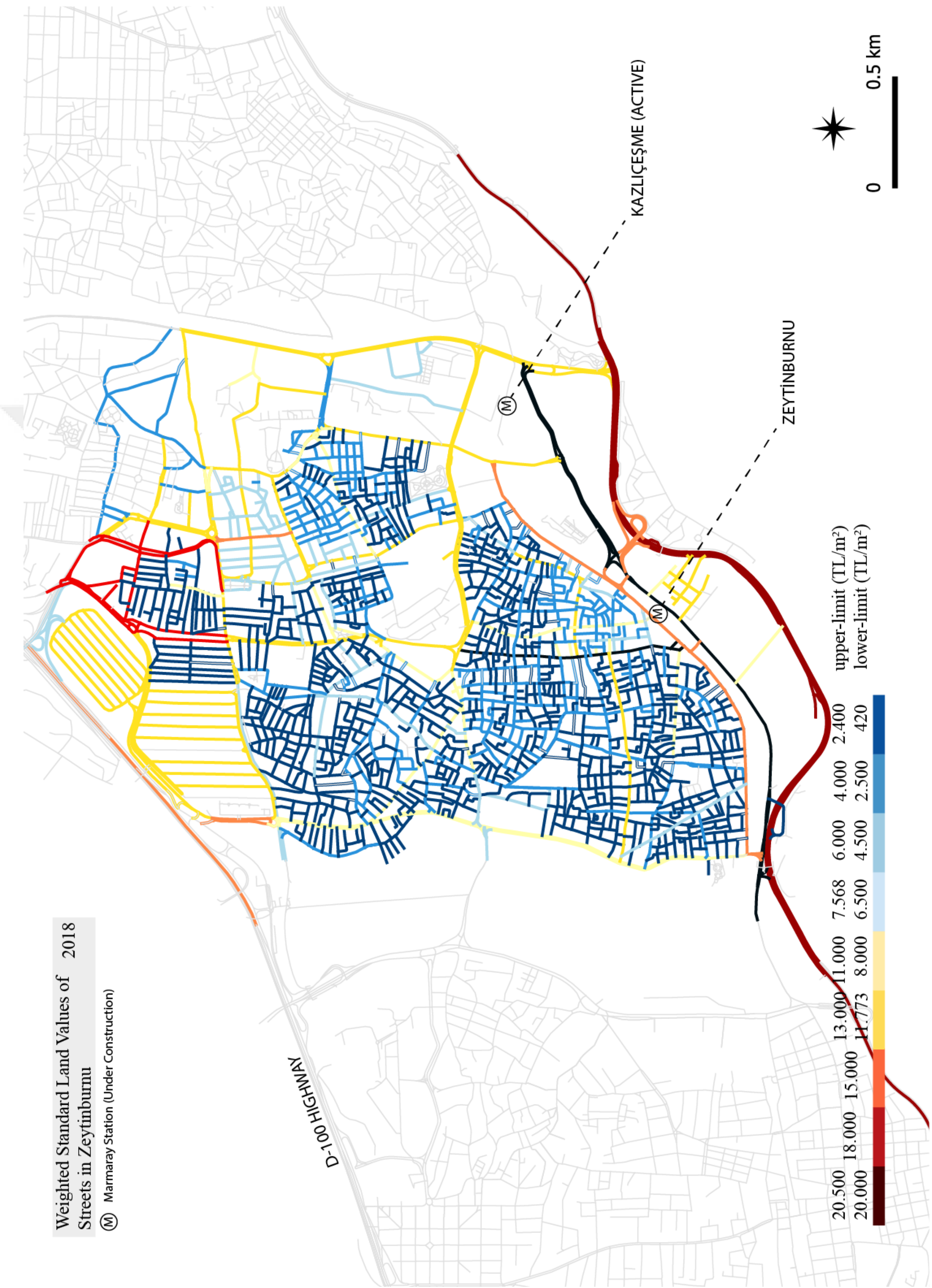
B.3.2.1 Weighted Standard Land Values of Streets – 2010



B.3.2.2 Weighted Standard Land Values of Streets – 2014

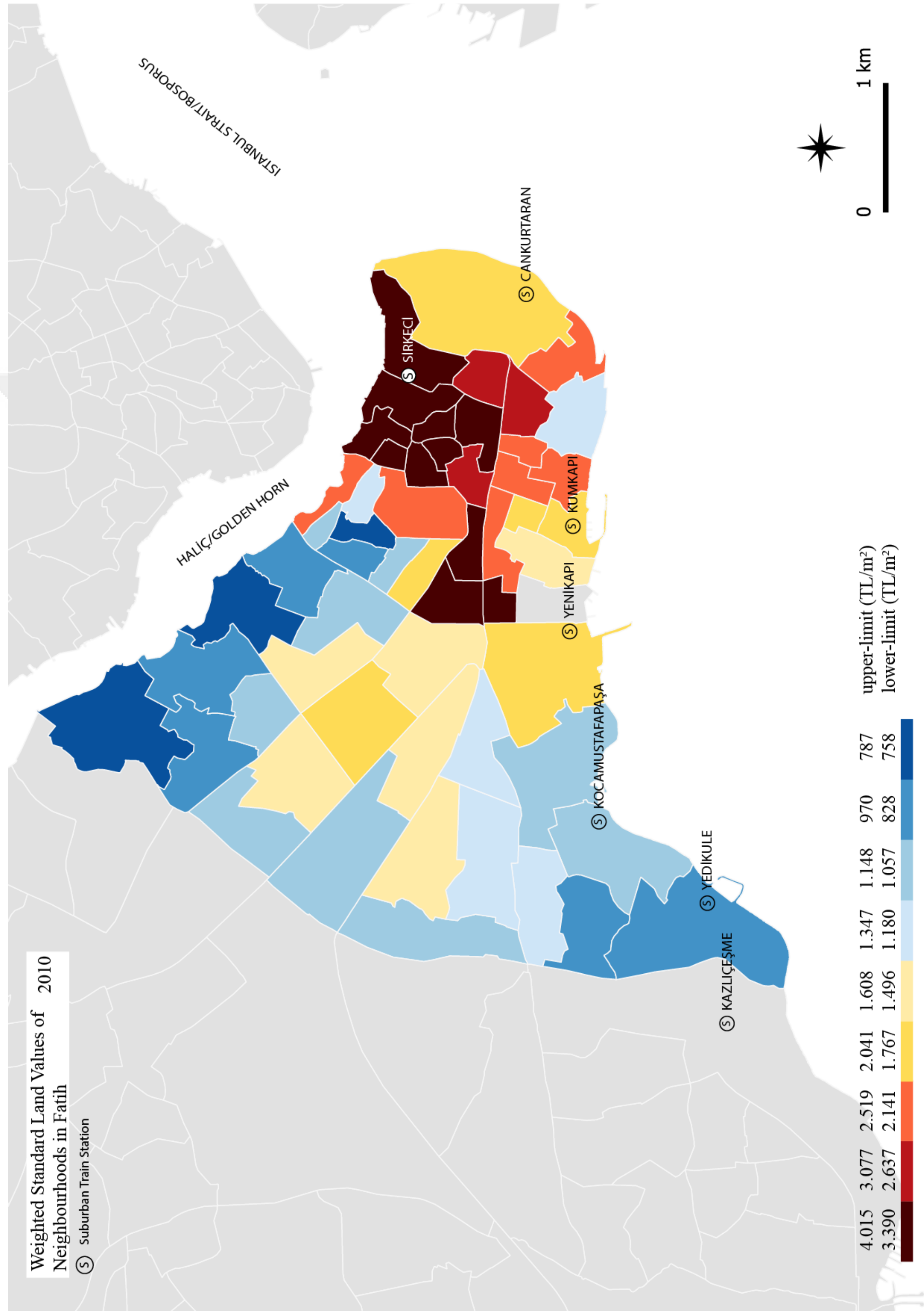


B.3.2.3 Weighted Standard Land Values of Streets – 2018

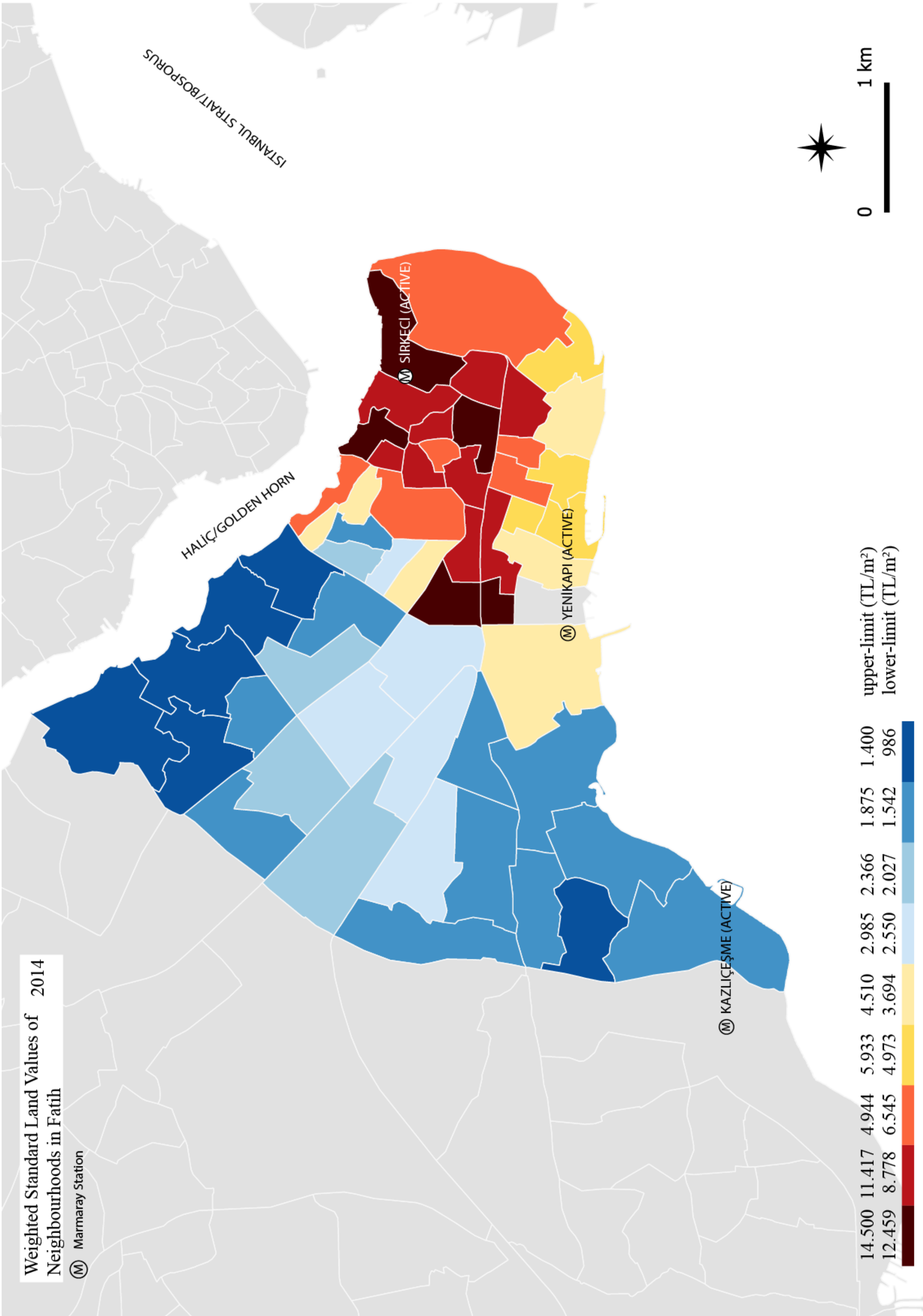


B.4 FATİH

B.4.1.1 Weighted Average Standard Land Values of Neighbourhoods – 2010



B.4.1.2 Weighted Average Standard Land Values of Neighbourhoods – 2014



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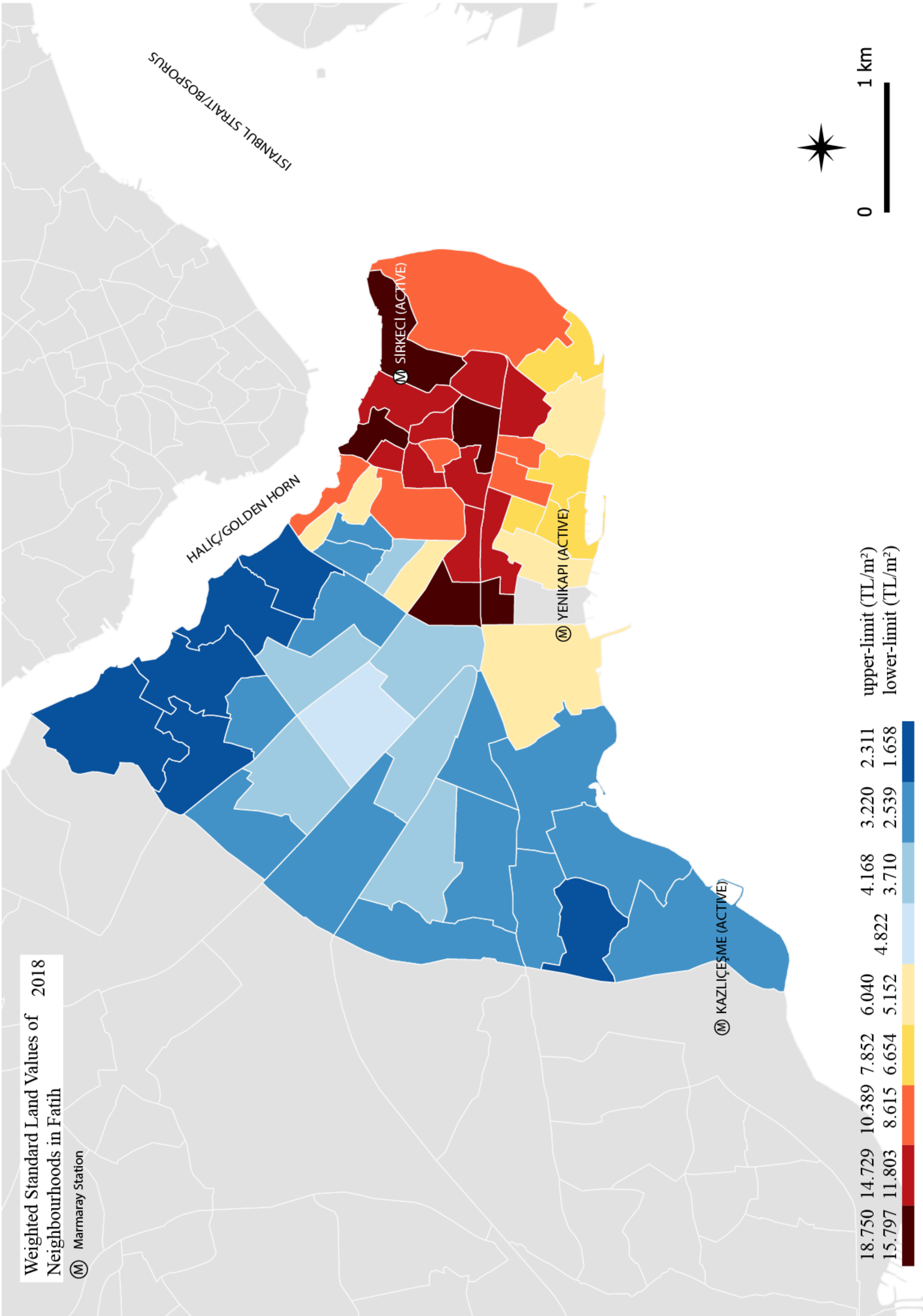
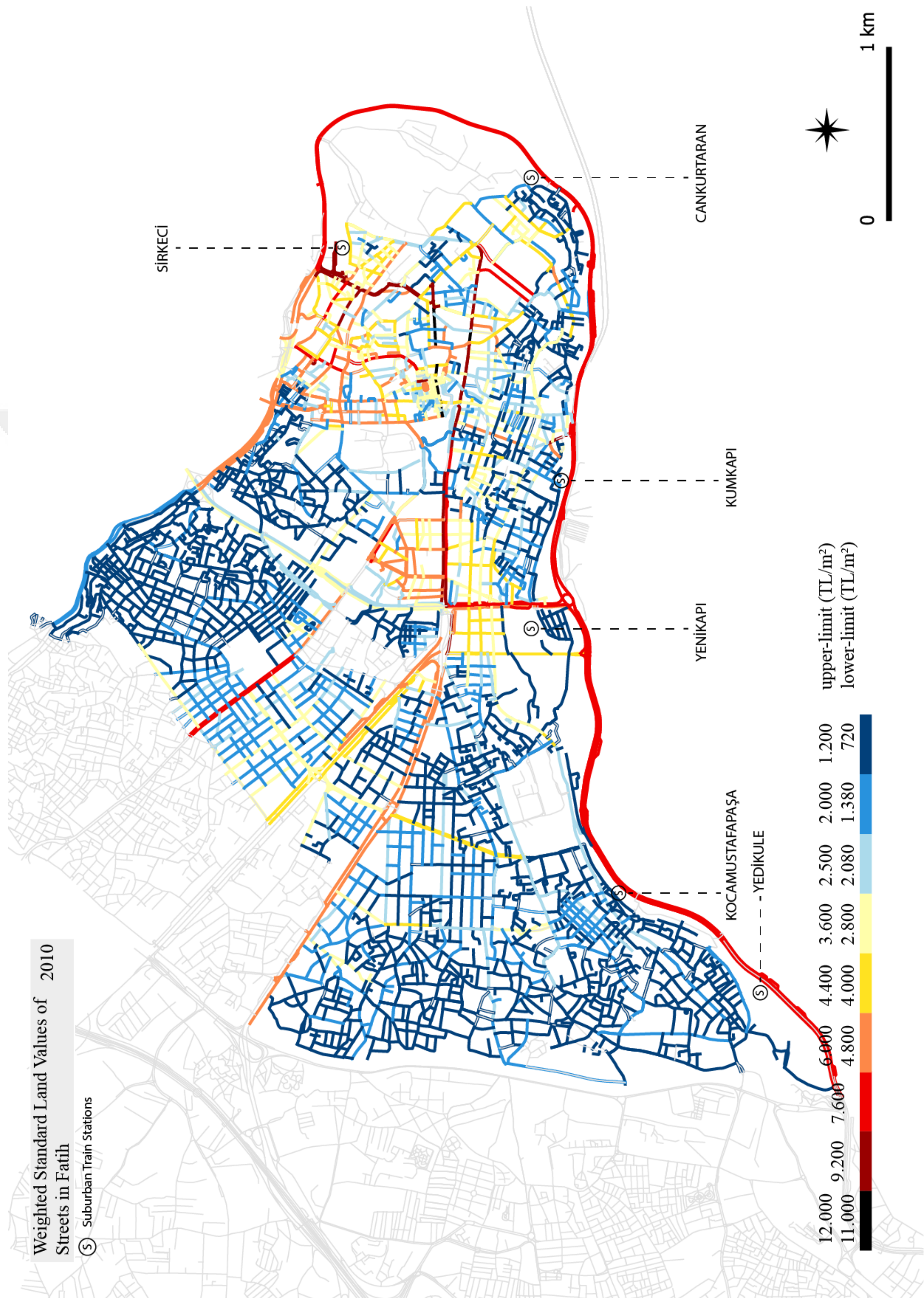
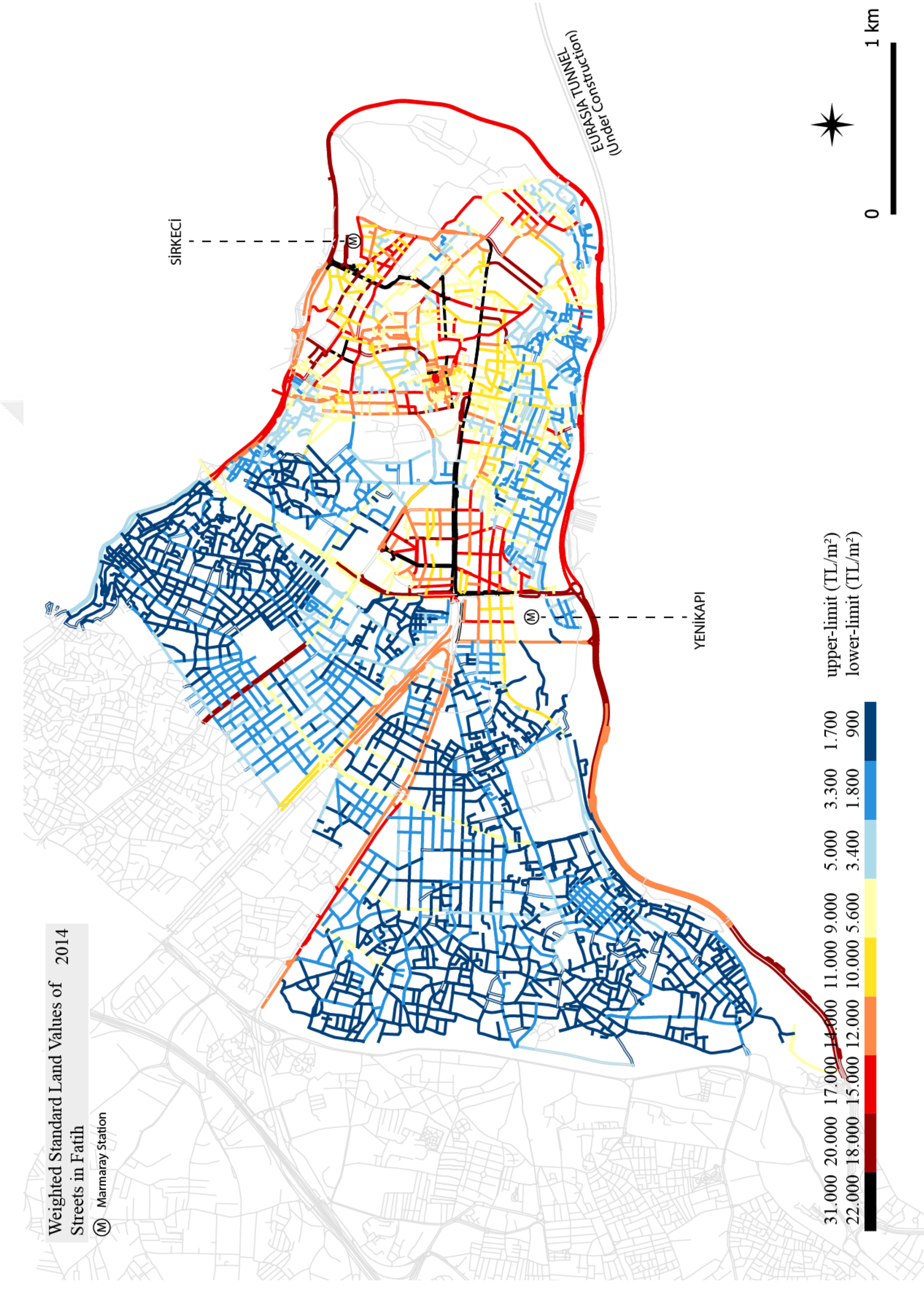


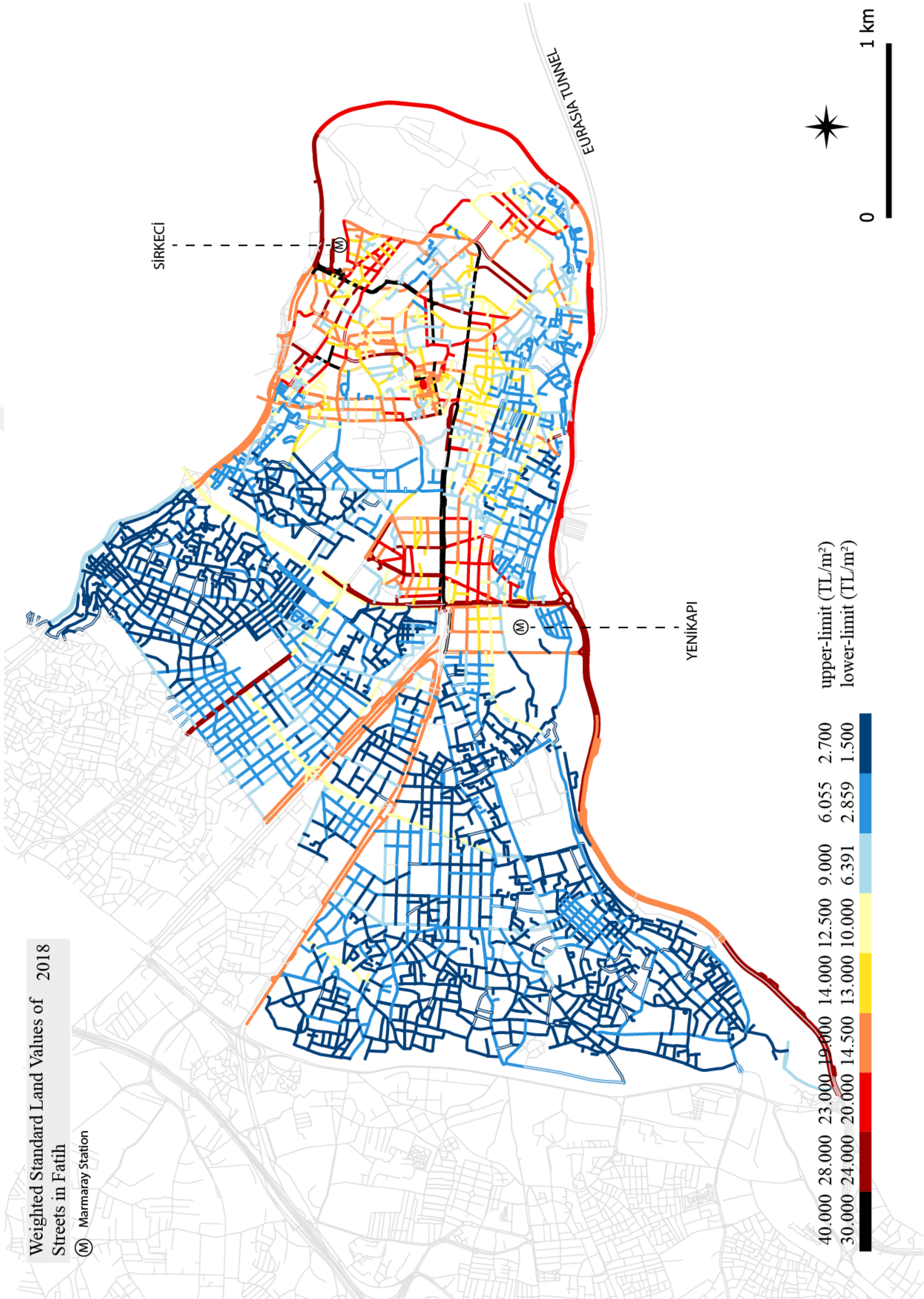
B.4.2.1 Weighted Standard Land Values of Streets – 2010



B.4.2.2 Weighted Standard Land Values of Streets – 2014

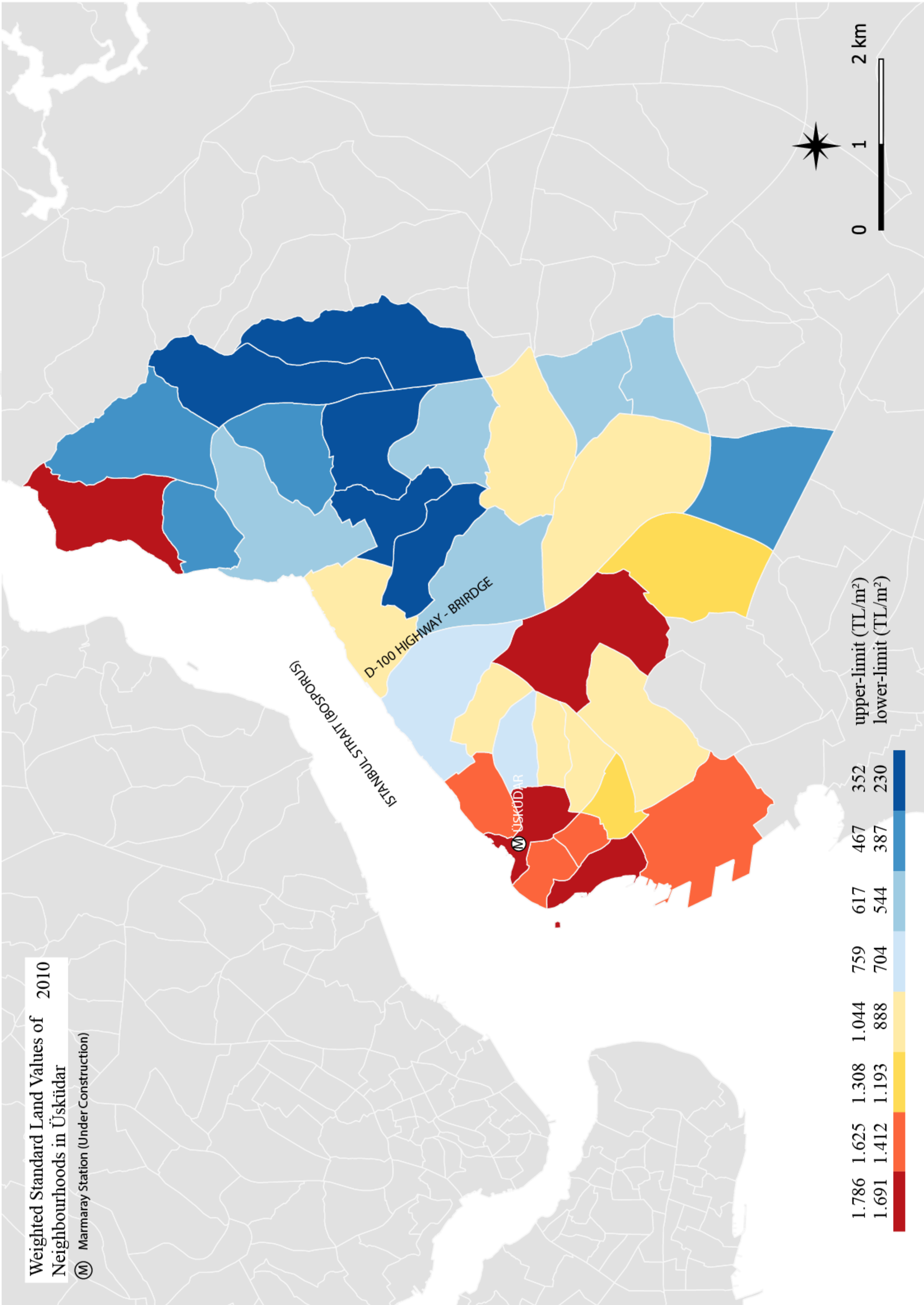


B.4.2.3 Weighted Standard Land Values of Streets – 2018

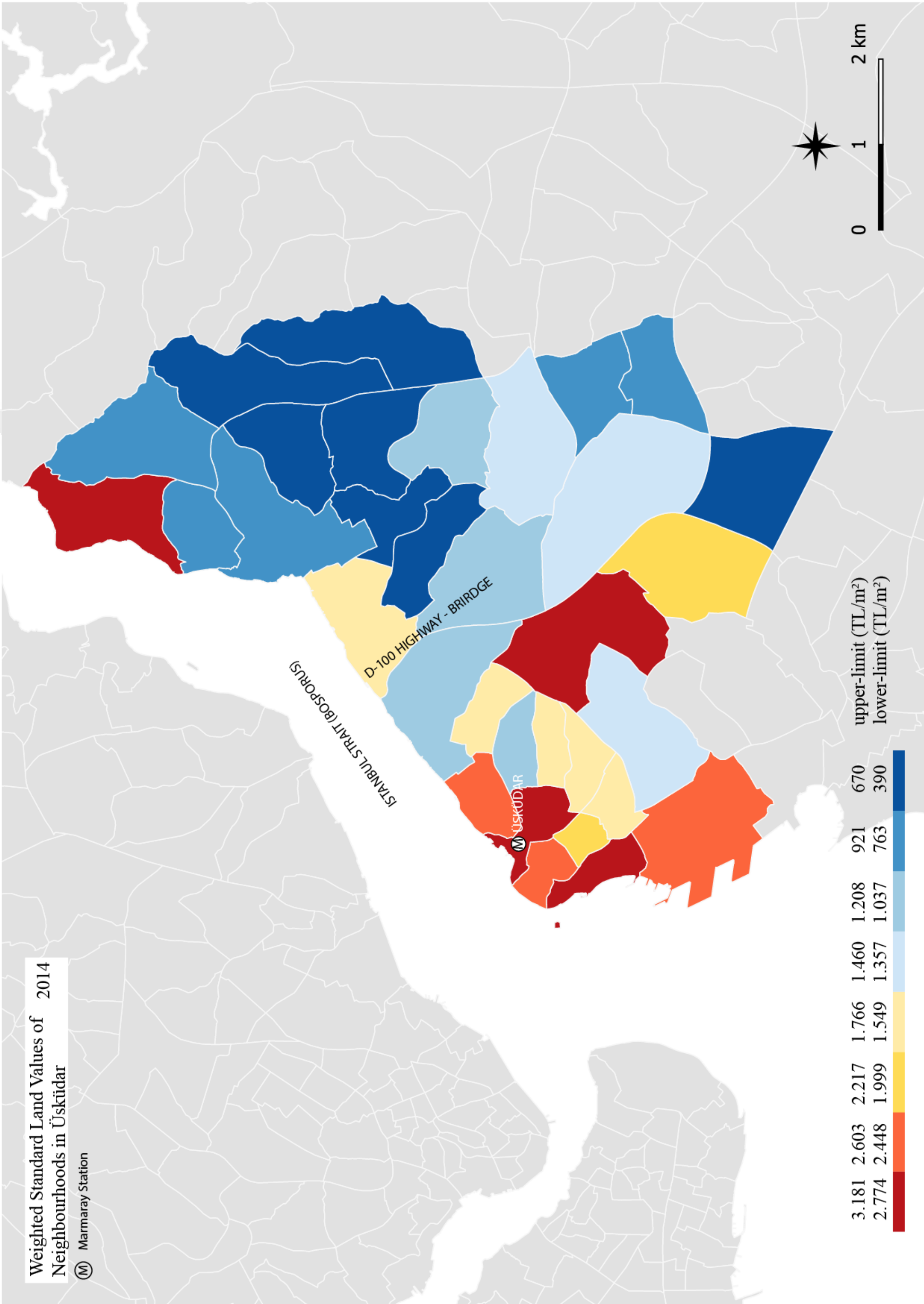


B.5 ÜSKÜDAR

B.5.1.1 Weighted Average Standard Land Values of Neighbourhoods – 2010



B.5.1.2 Weighted Average Standard Land Values of Neighbourhoods – 2014



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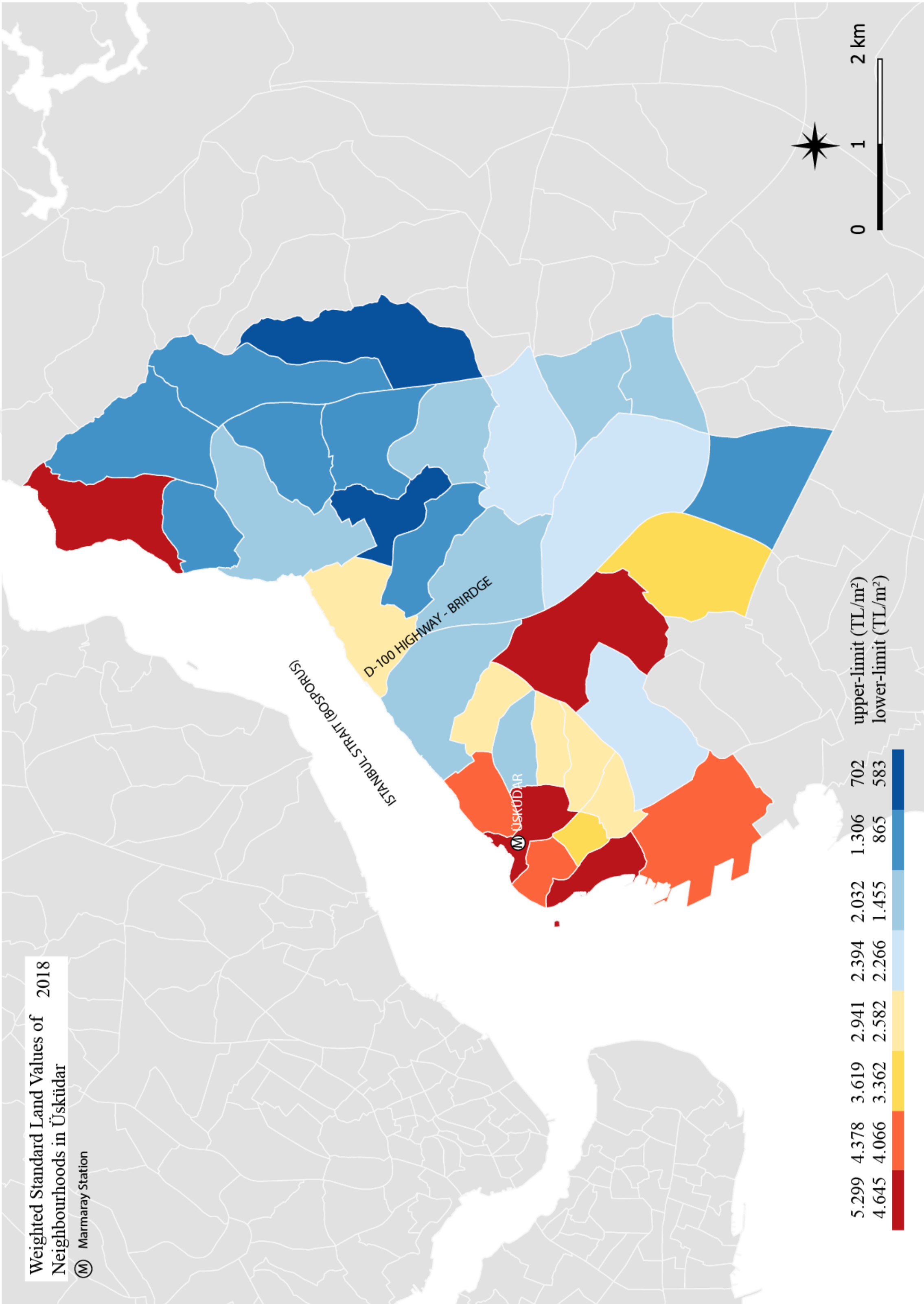
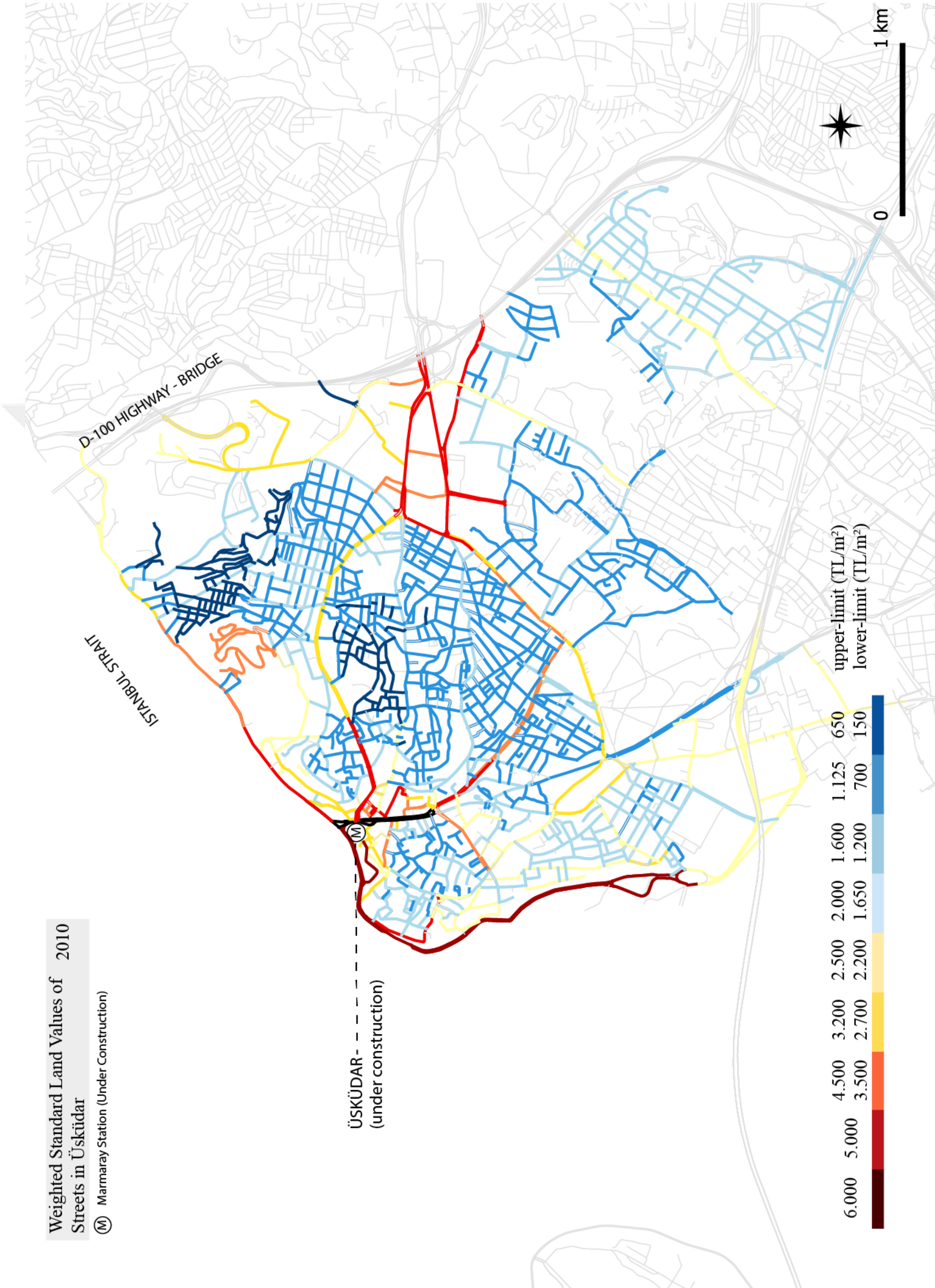
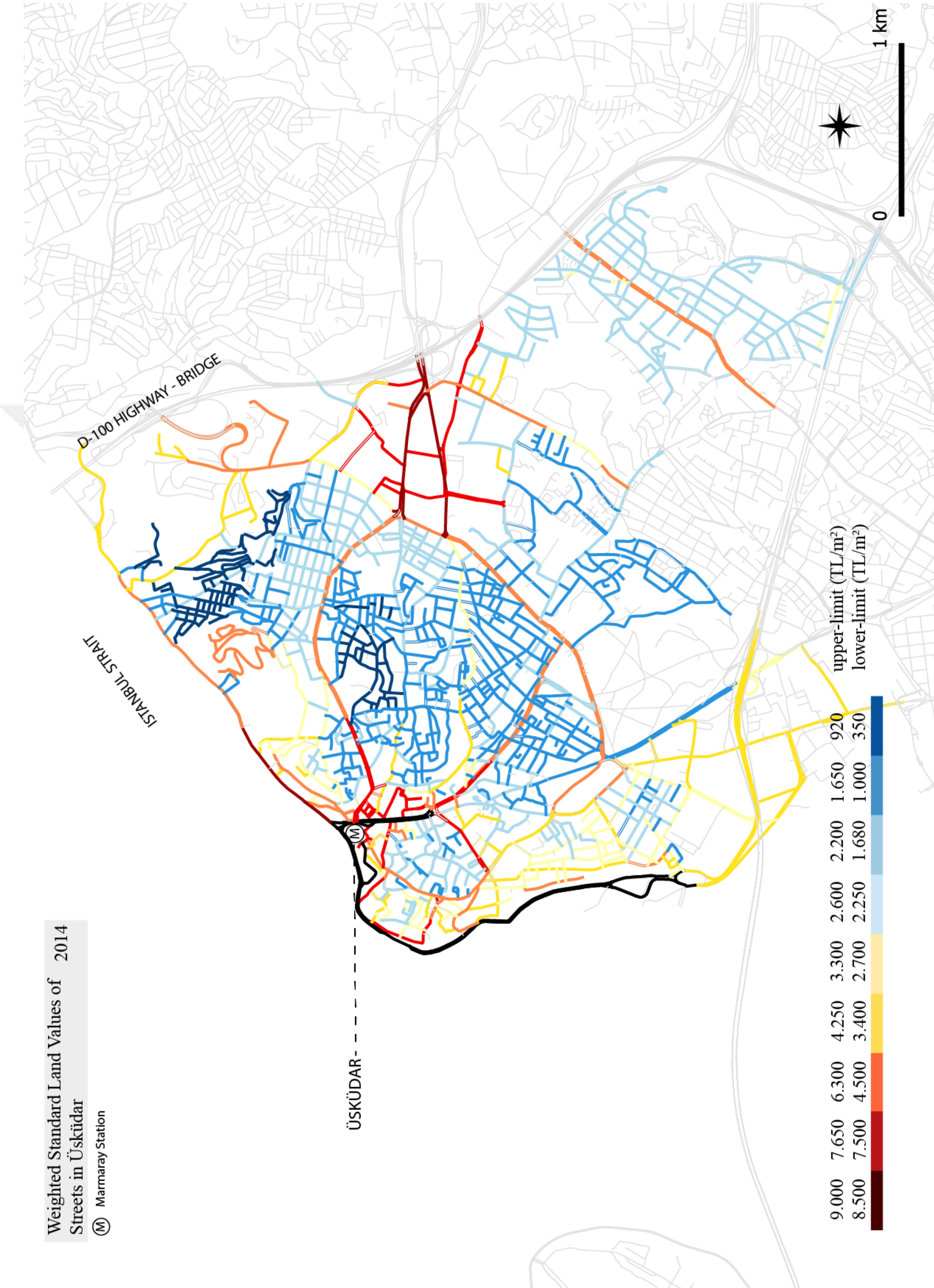


B.5.2.1 Weighted Standard Land Values of Streets – 2010



B.5.2.2 Weighted Standard Land Values of Streets – 2014



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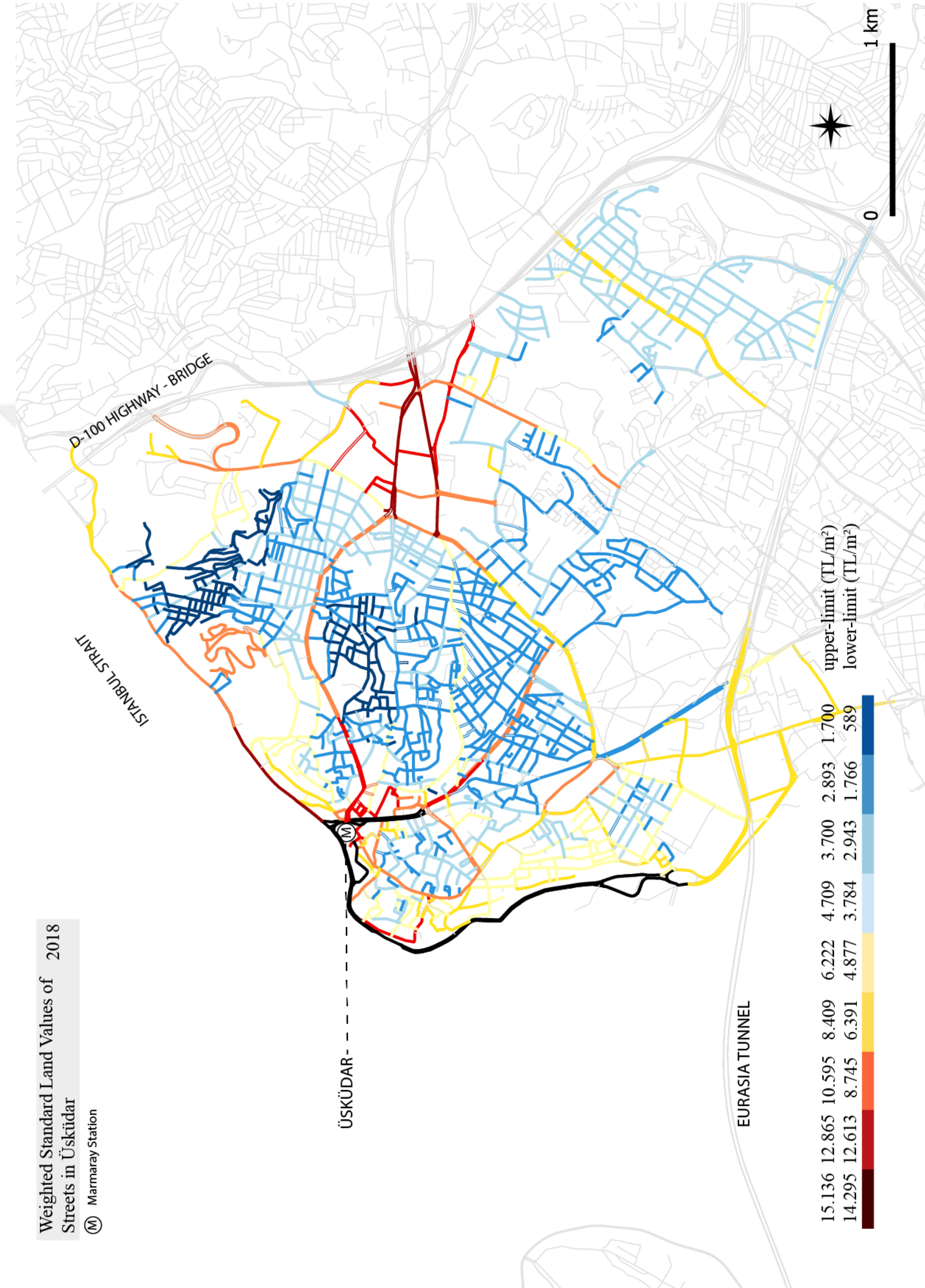
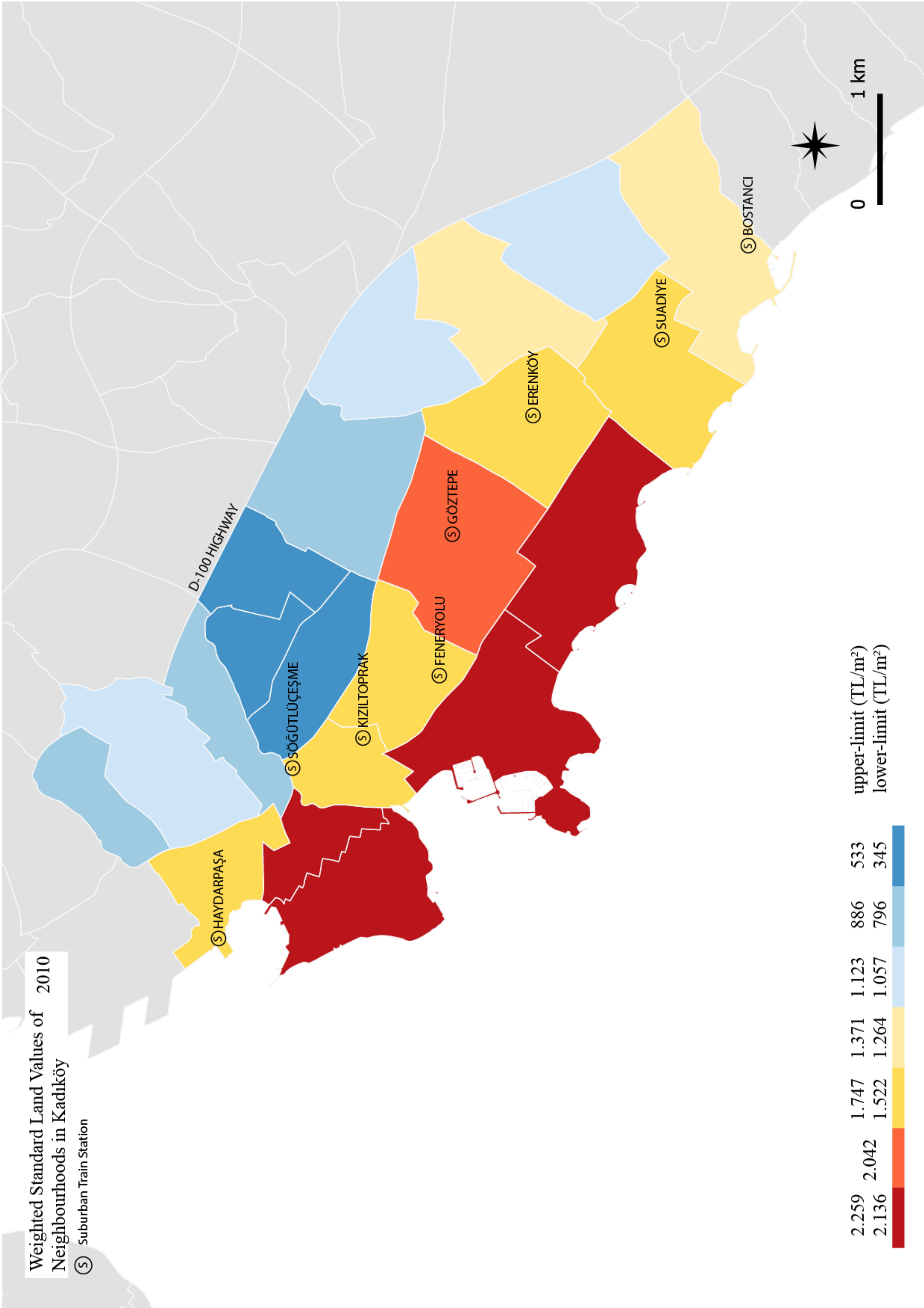
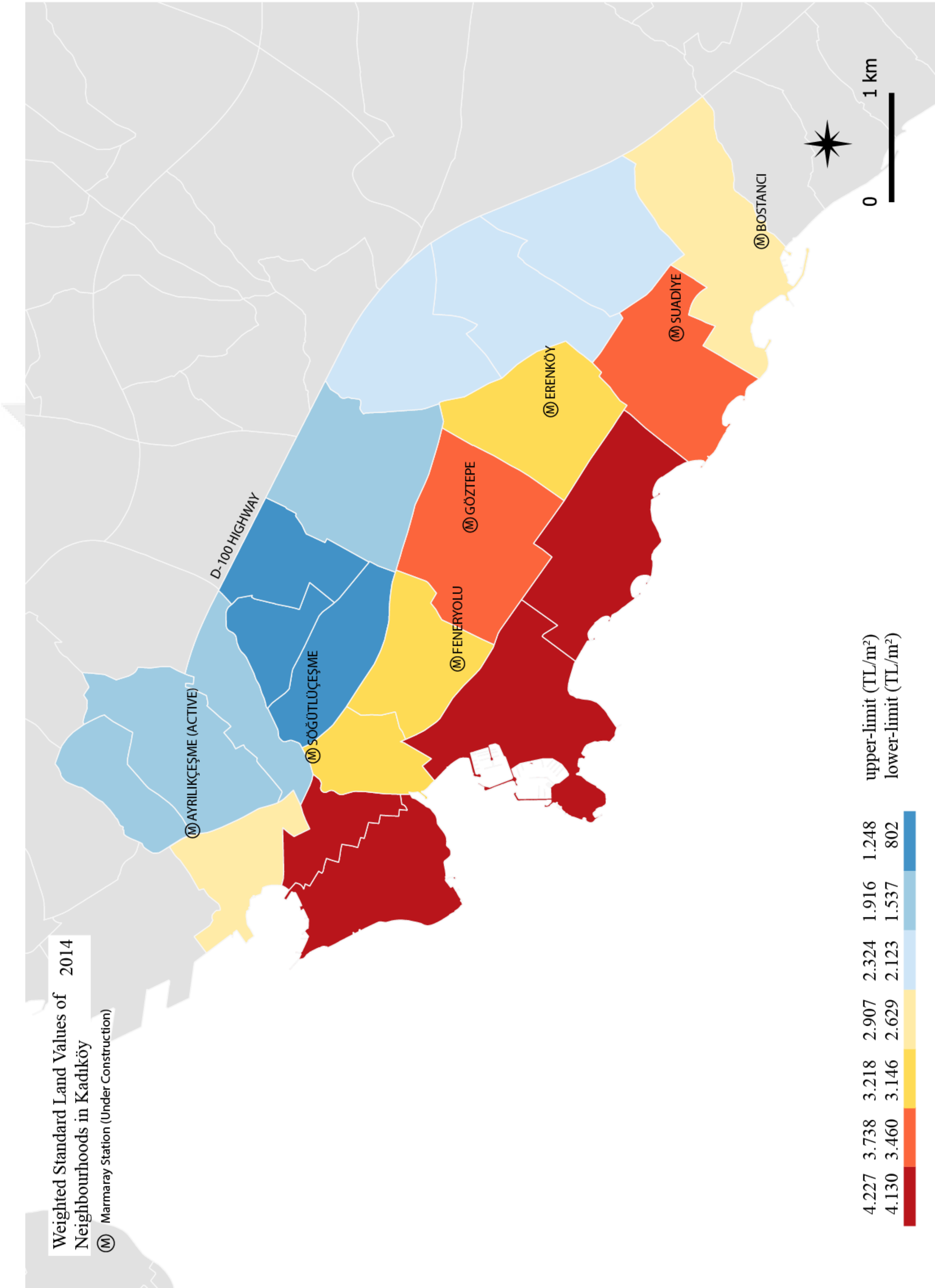


B.6 KADIKÖY

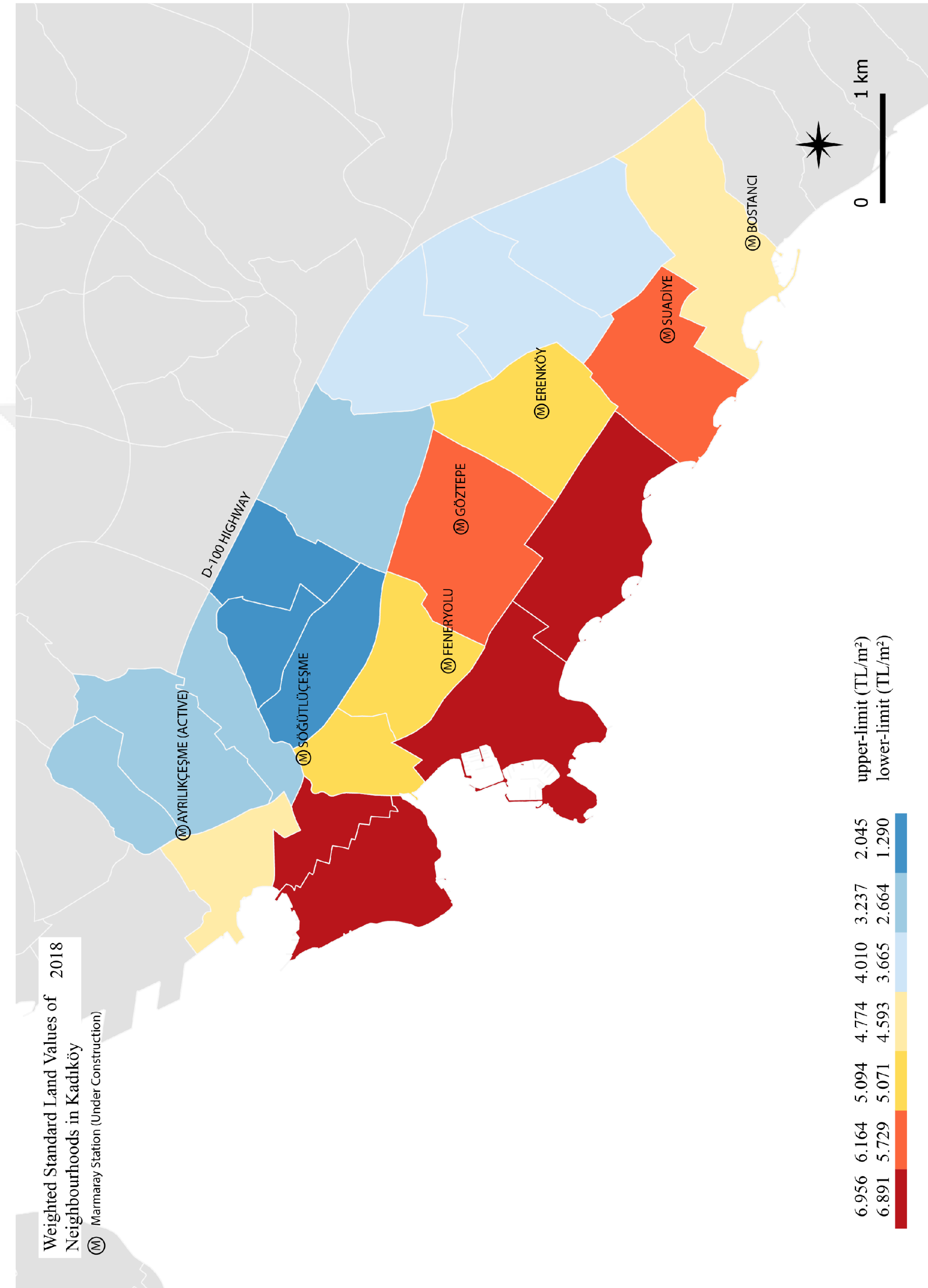
B.6.1.1 Weighted Average Standard Land Values of Neighbourhoods – 2010



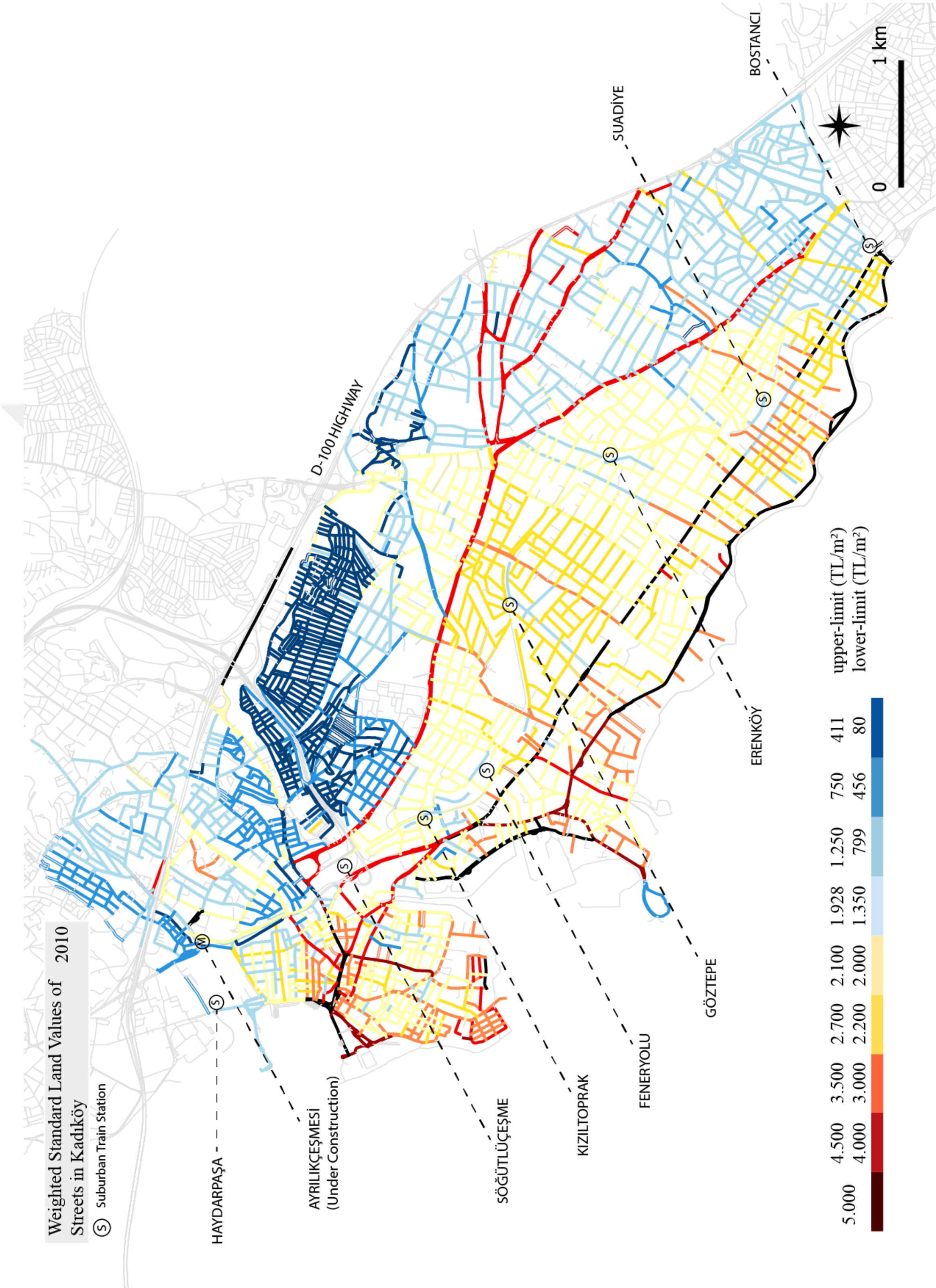
B.6.1.2 Weighted Average Standard Land Values of Neighbourhoods – 2014



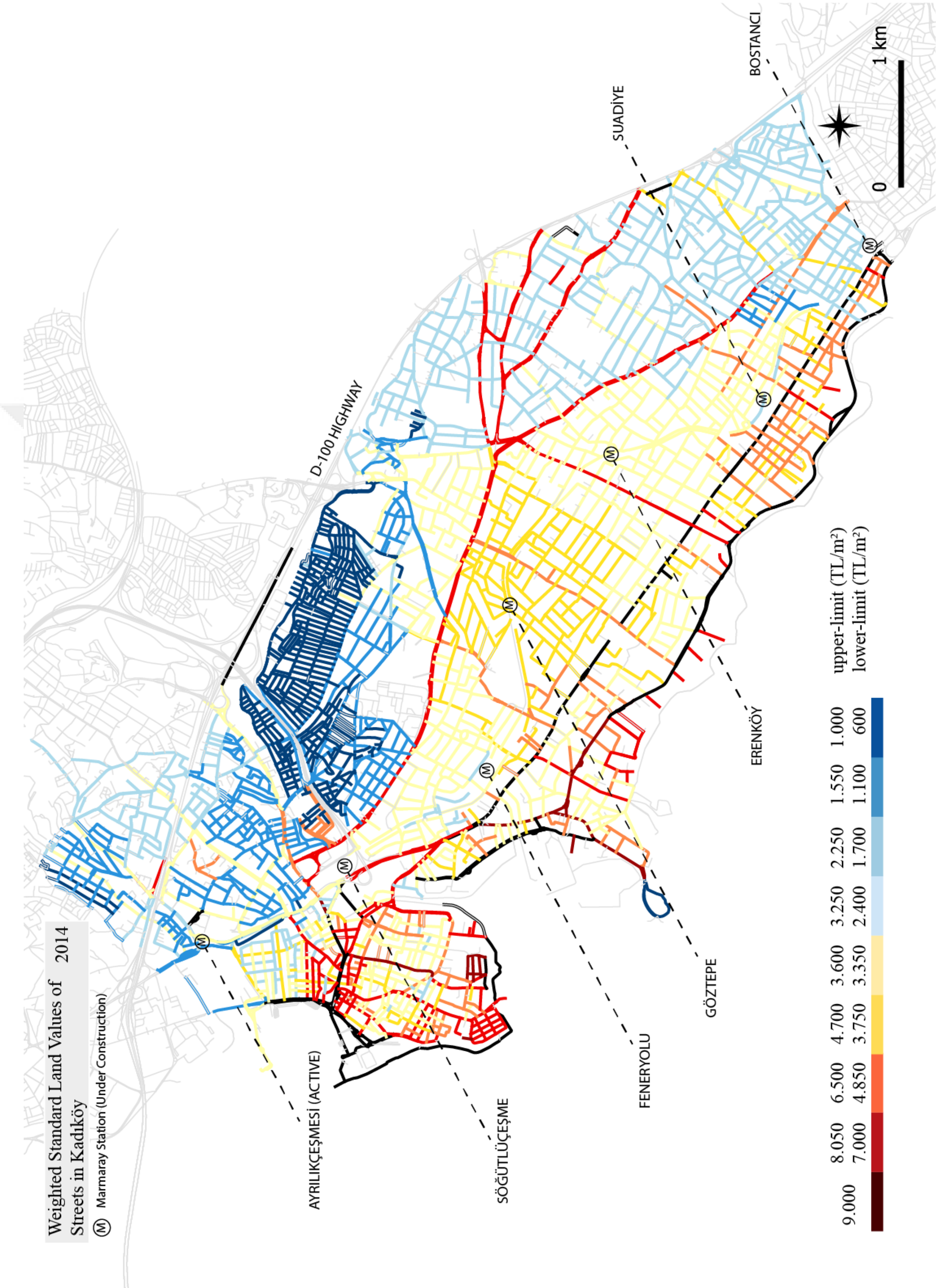
B.6.1.3 Weighted Average Standard Land Values of Neighbourhoods – 2018



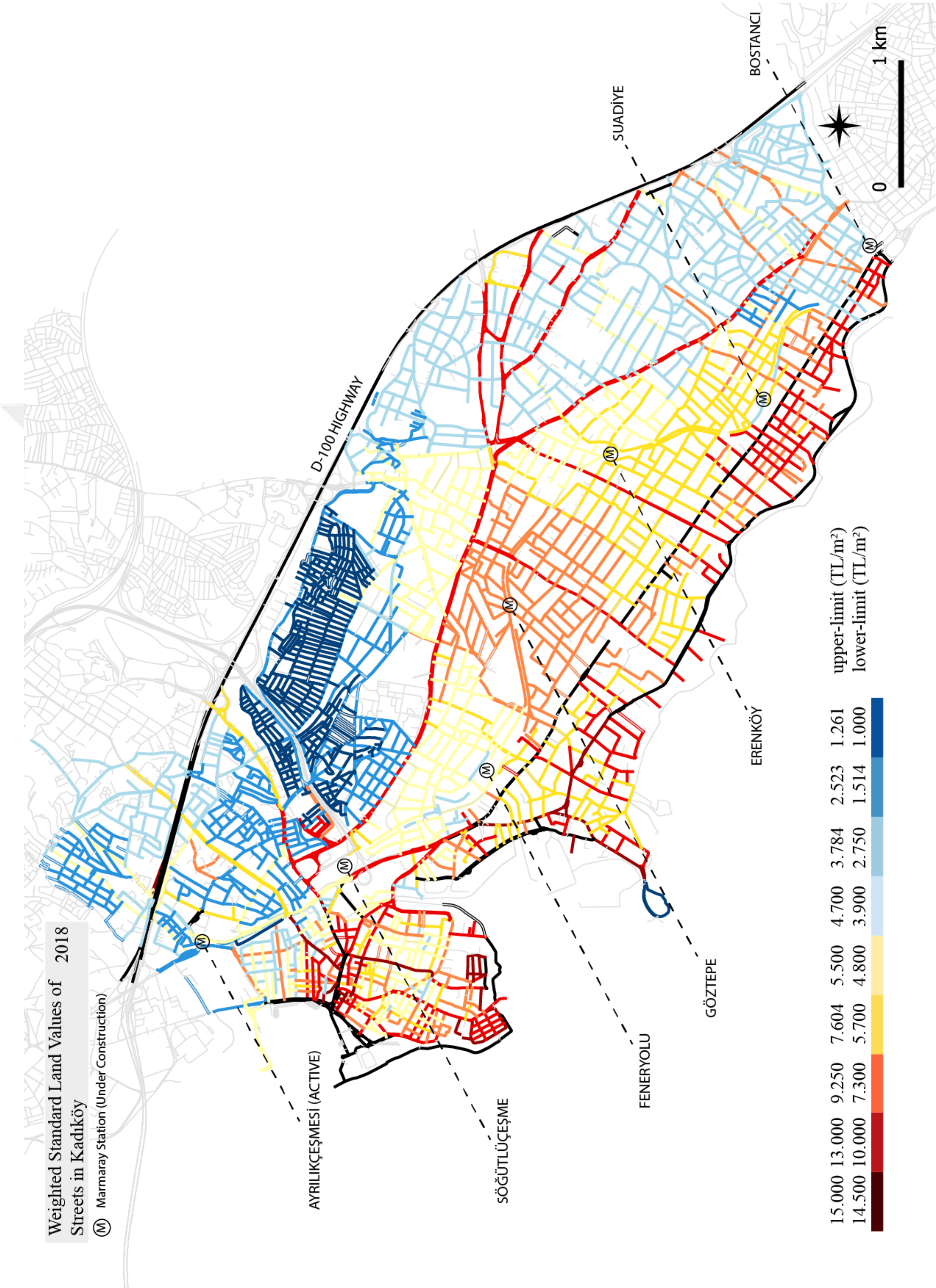
B.6.1.1 Weighted Standard Land Values of Streets – 2010



B.6.1.2 Weighted Standard Land Values of Streets – 2014

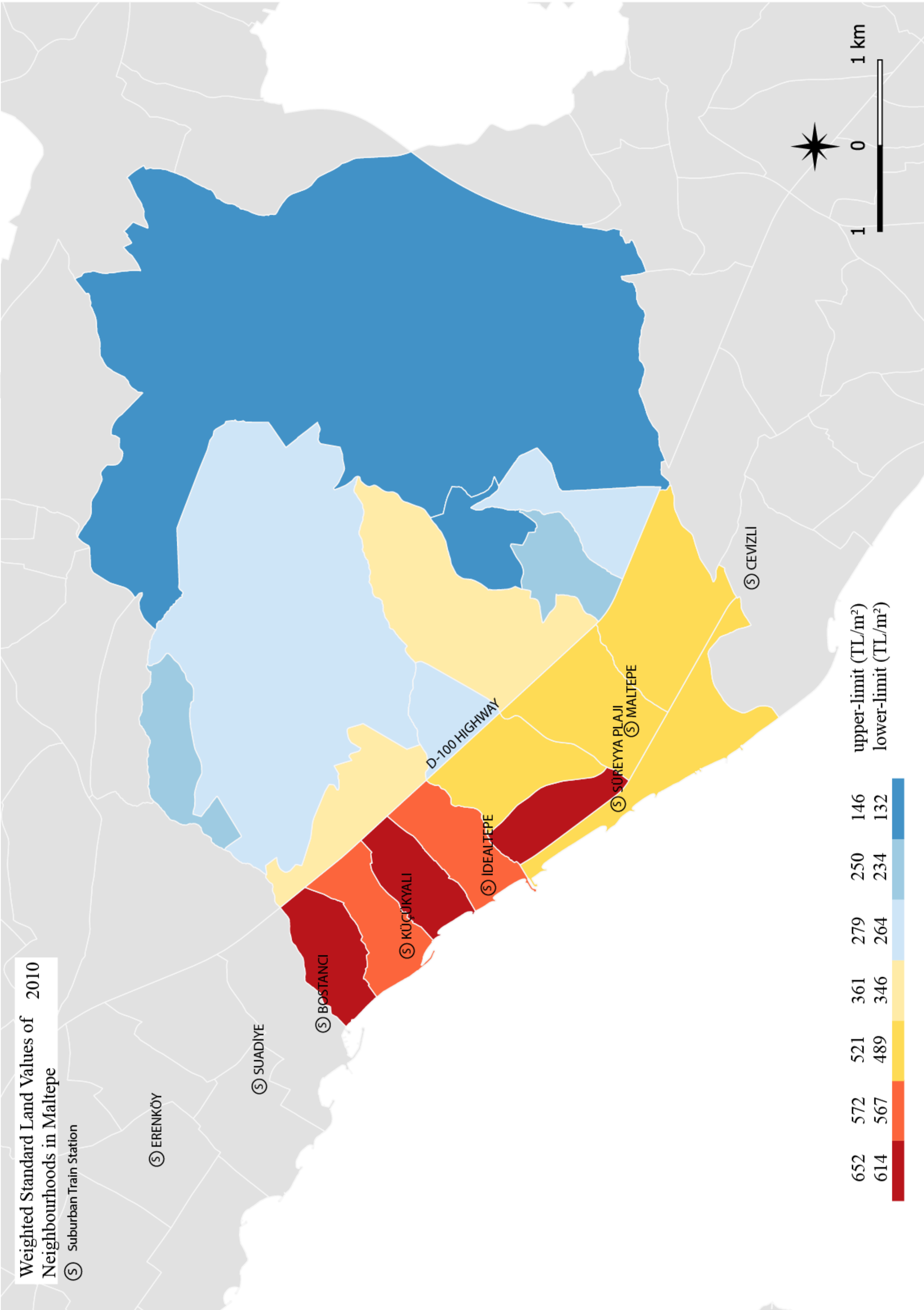


B.6.1.3 Weighted Standard Land Values of Streets – 2018

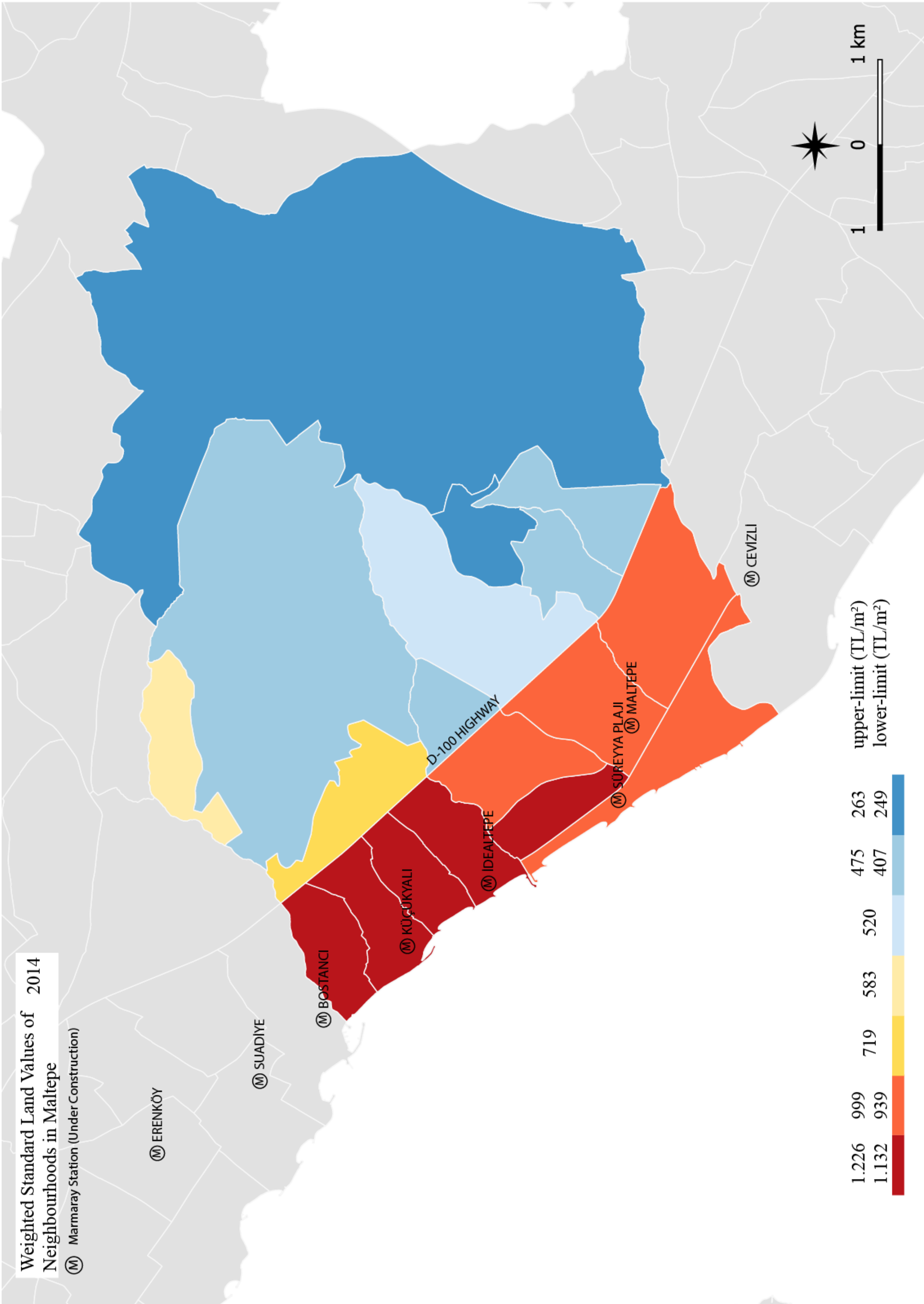


B.7 MALTEPE

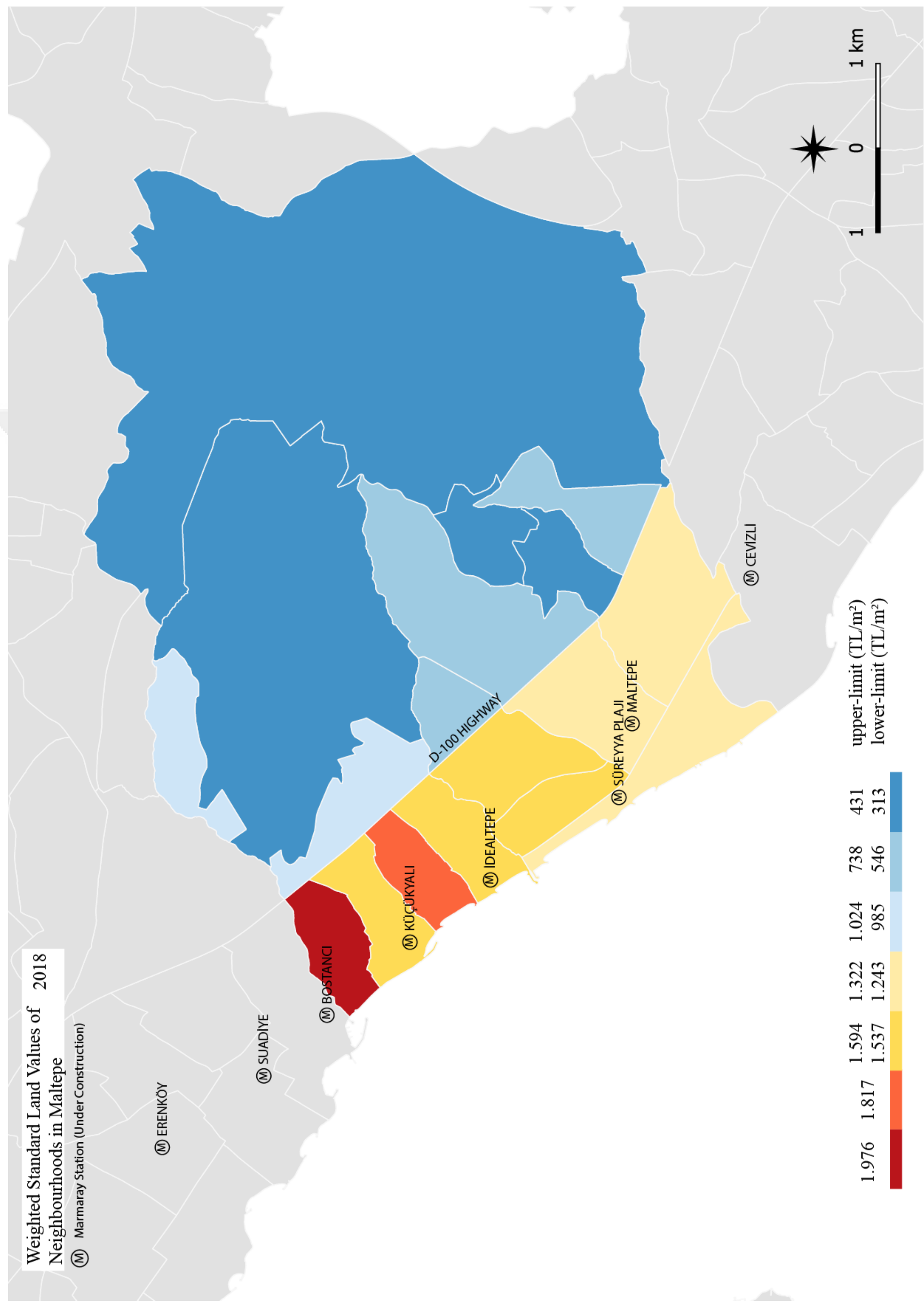
B.7.1.1 Weighted Average Standard Land Values of Neighbourhoods – 2010



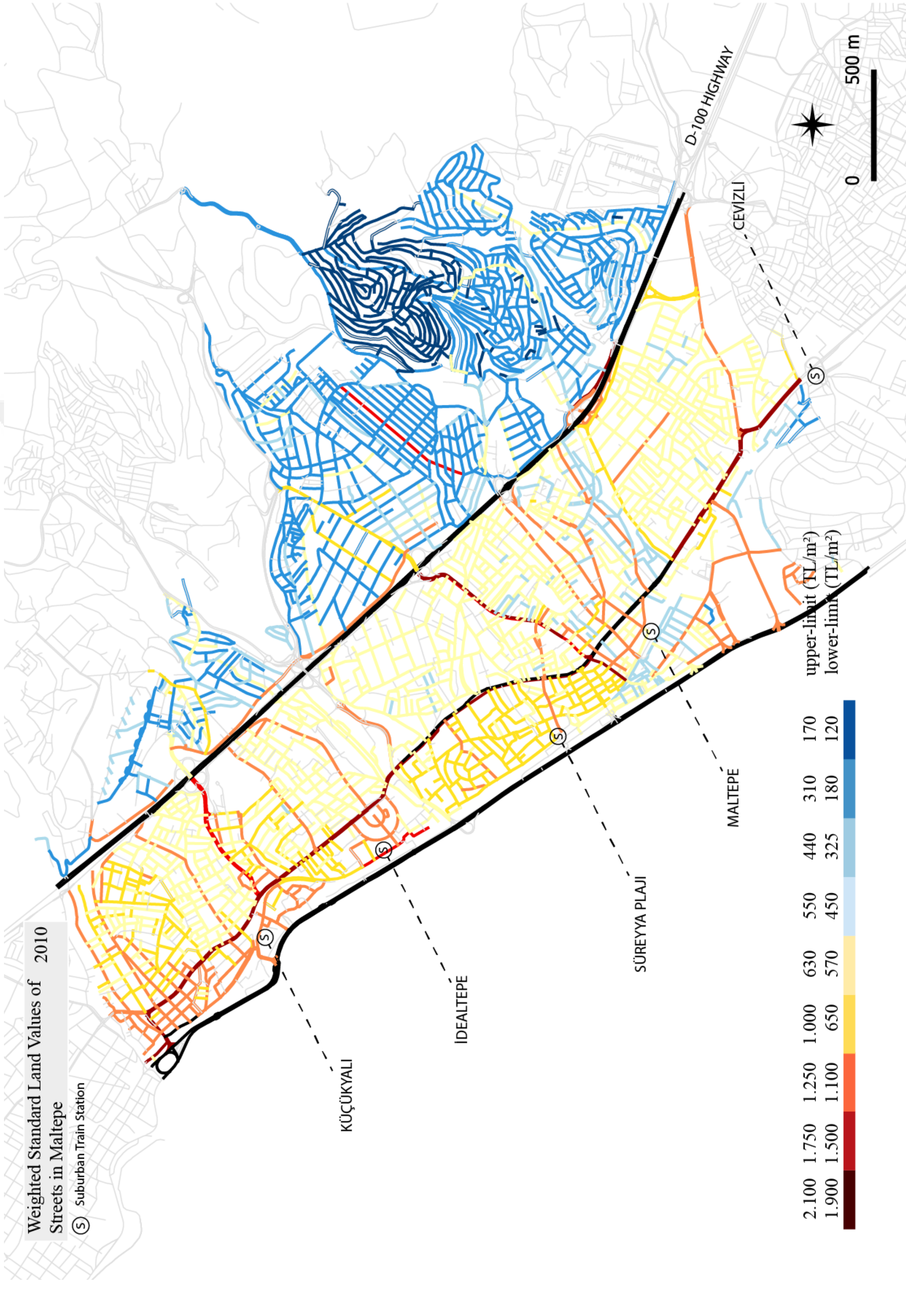
B.7.1.2 Weighted Average Standard Land Values of Neighbourhoods – 2014



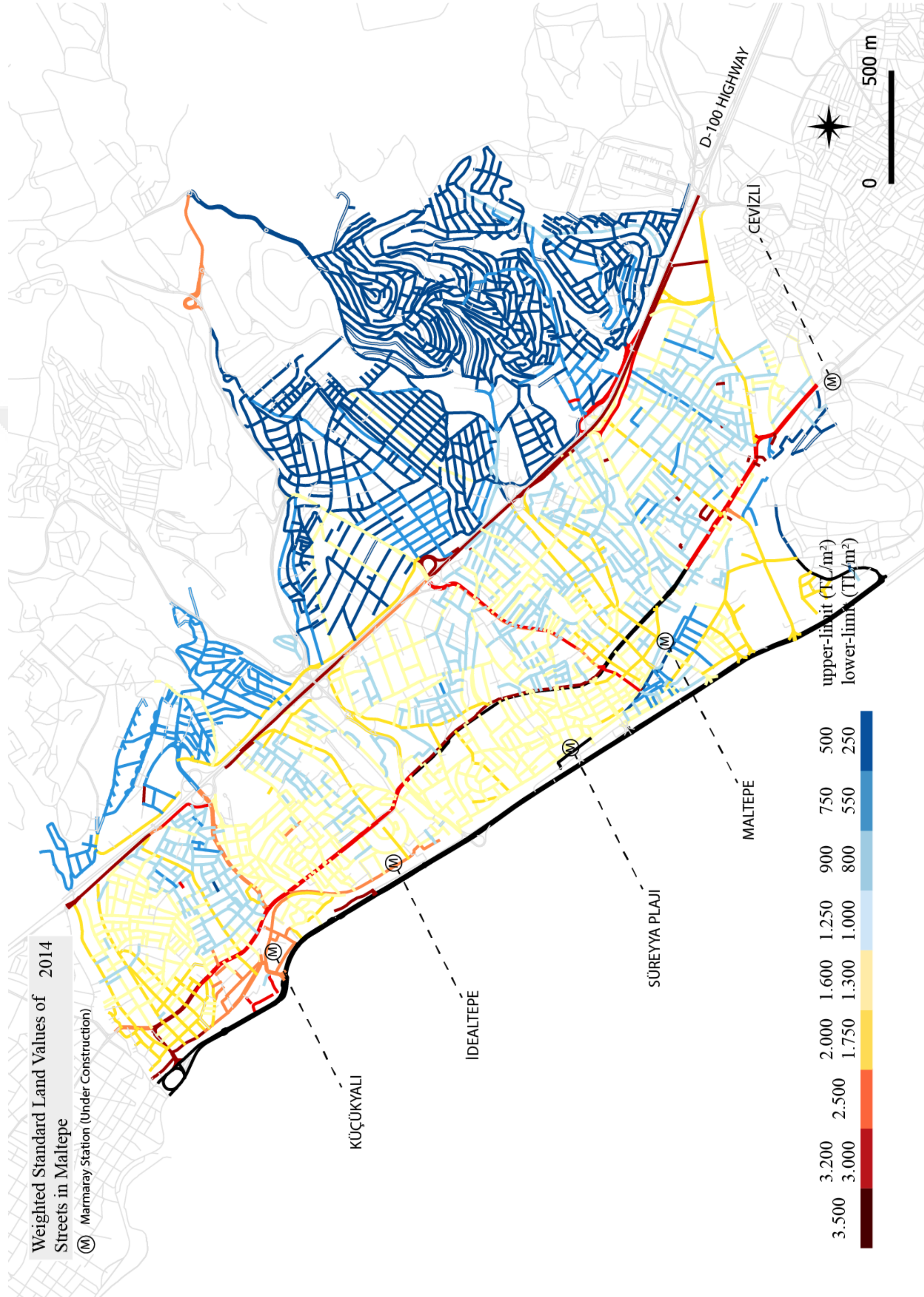
B.7.1.3 Weighted Average Standard Land Values of Neighbourhoods – 2018



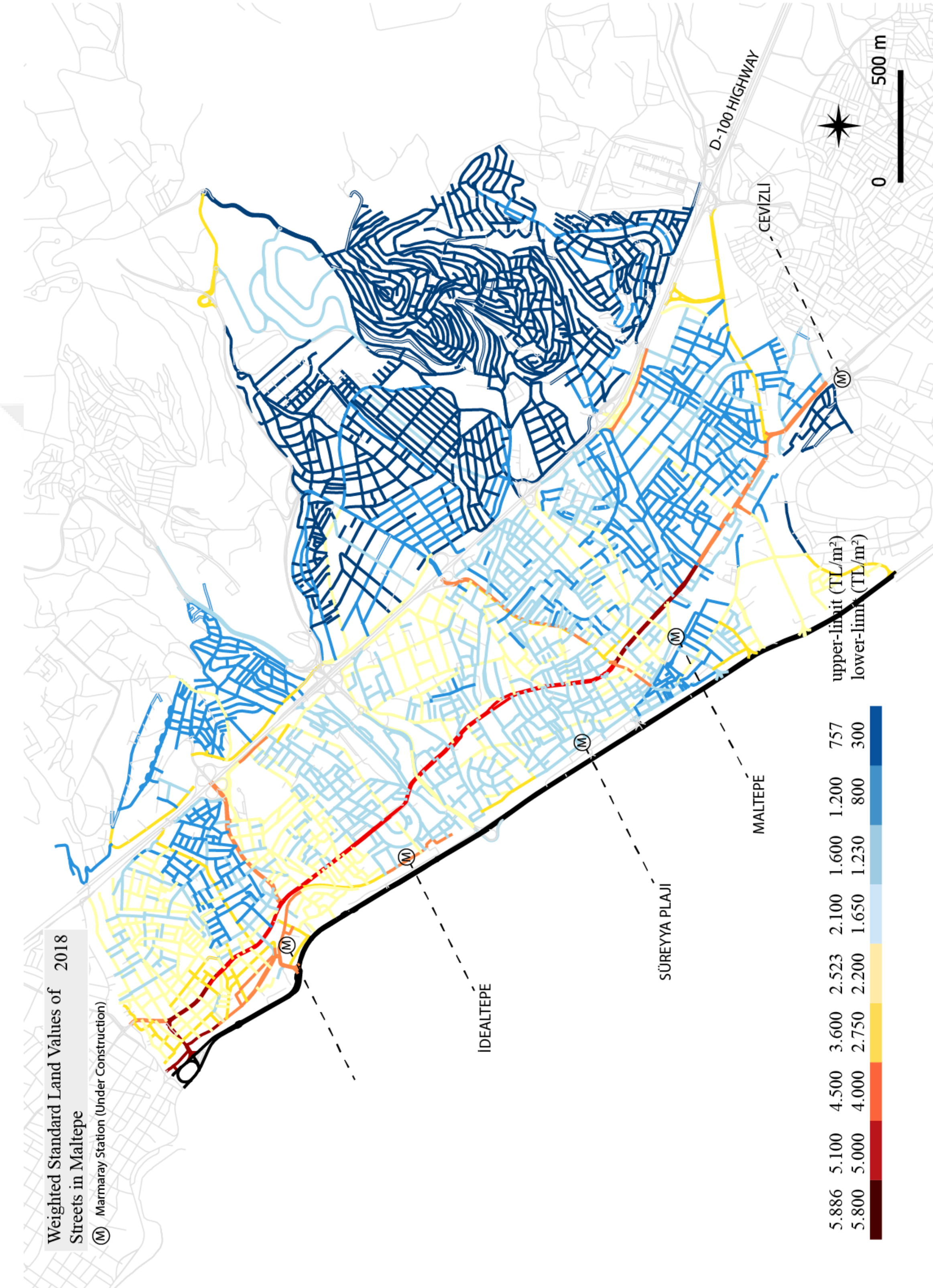
B.7.2.1 Weighted Standard Land Values of Street – 2010



B.7.2.2 Weighted Standard Land Values of Street – 2014

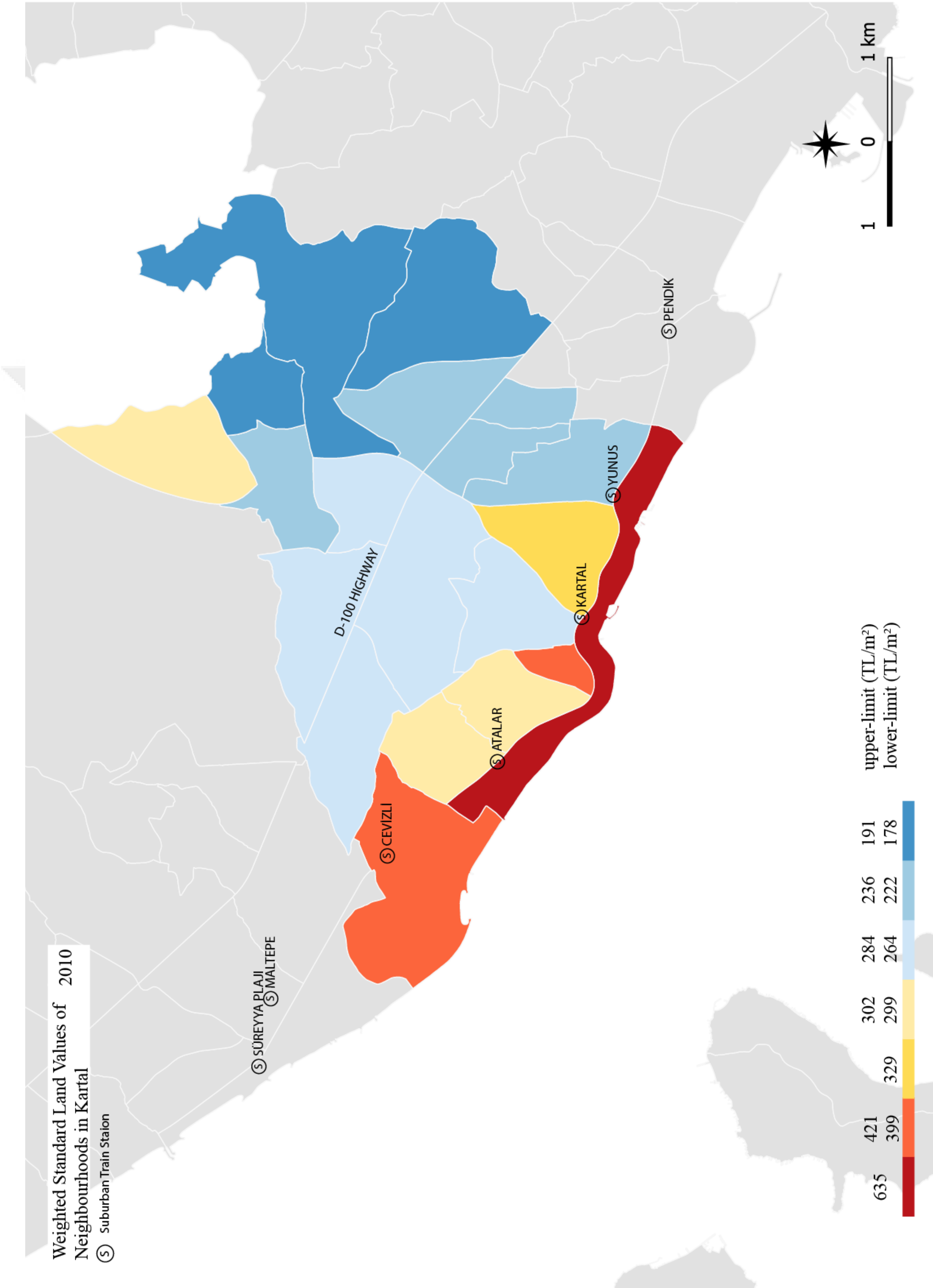


B.7.2.3 Weighted Standard Land Values of Street – 2018

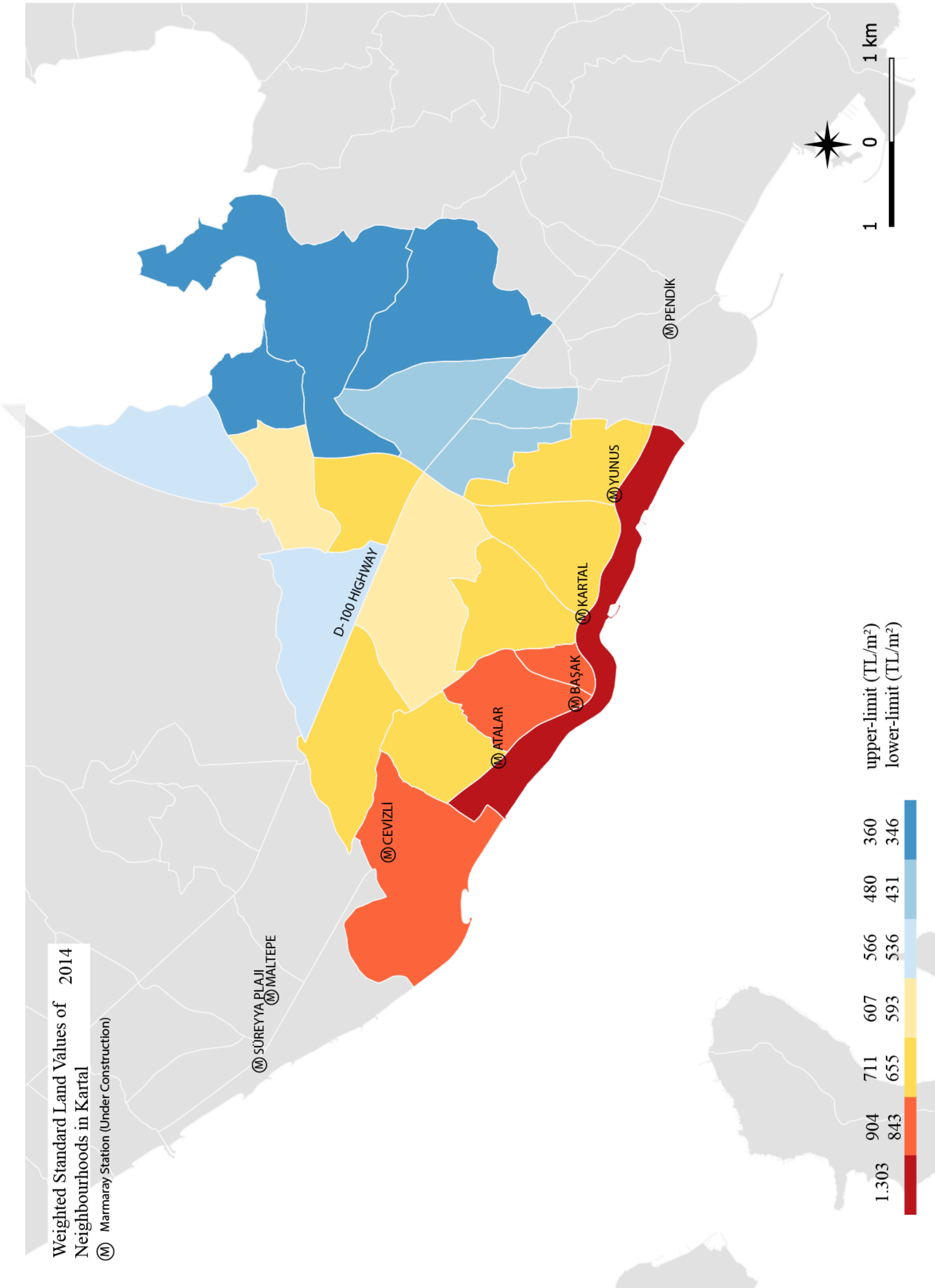


B.8 KARTAL

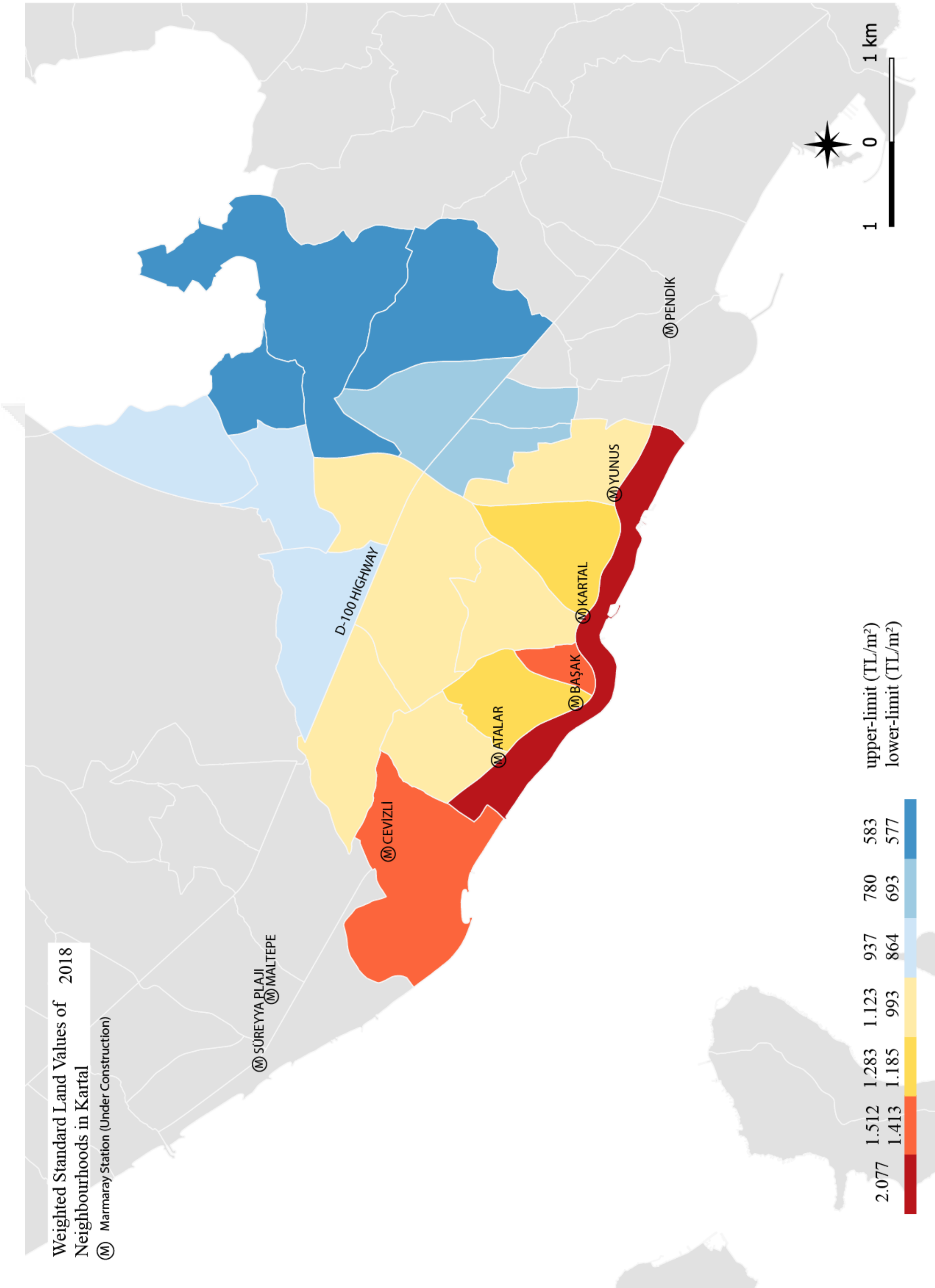
B.8.1.1 Weighted Average Standard Land Values of Neighbourhoods – 2010



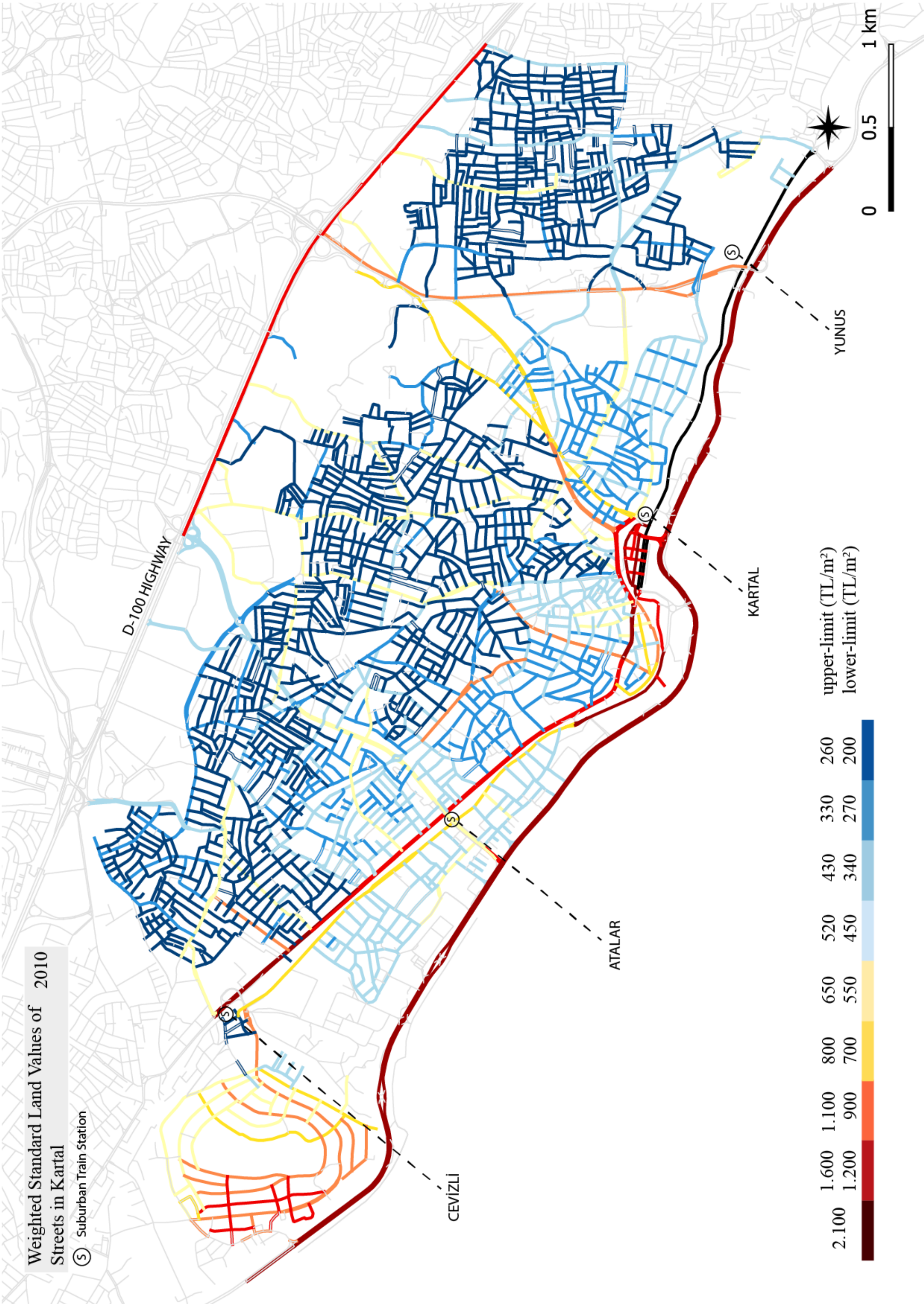
B.8.1.2 Weighted Average Standard Land Values of Neighbourhoods – 2014



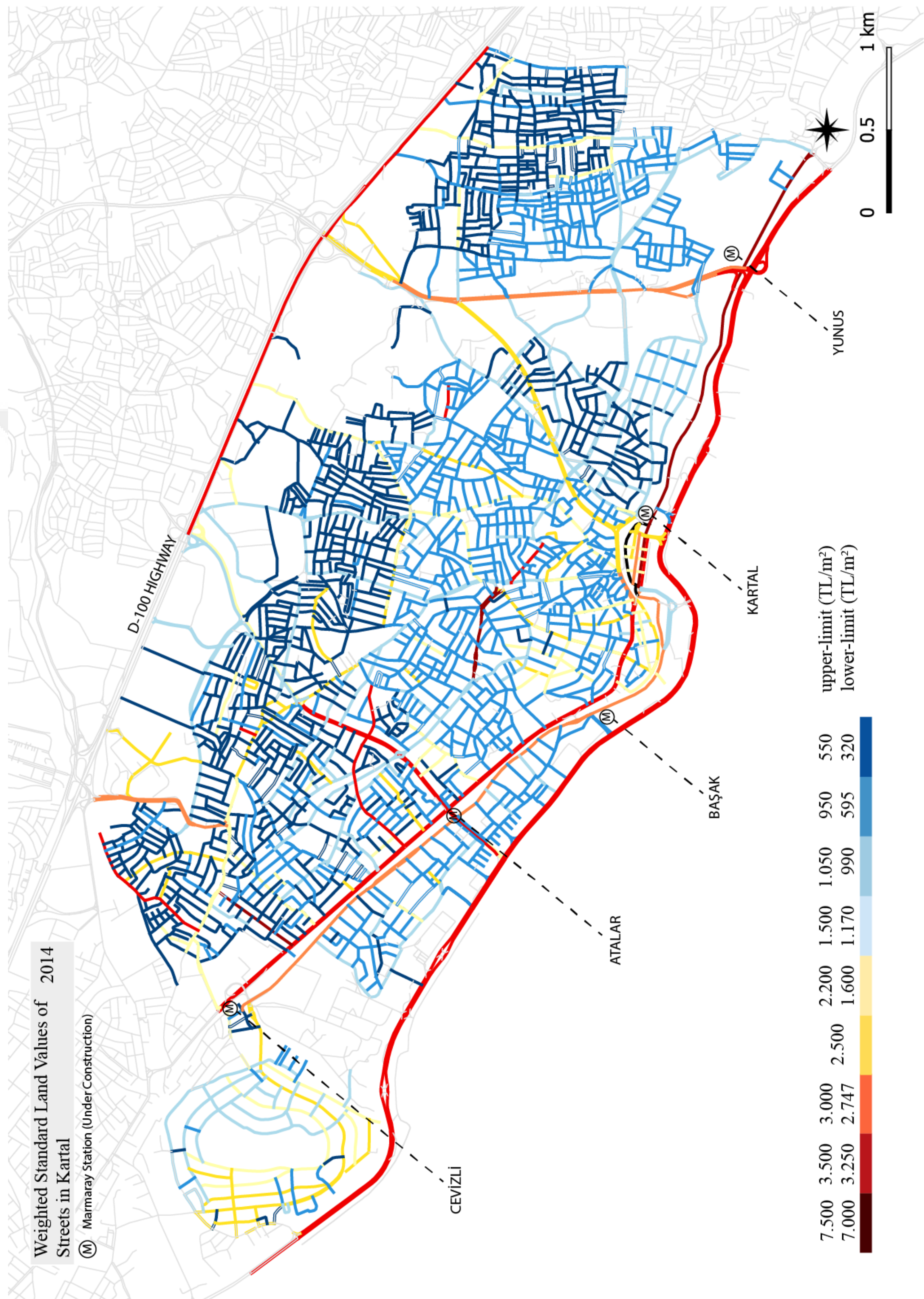
B.8.1.3 Weighted Average Standard Land Values of Neighbourhoods – 2018



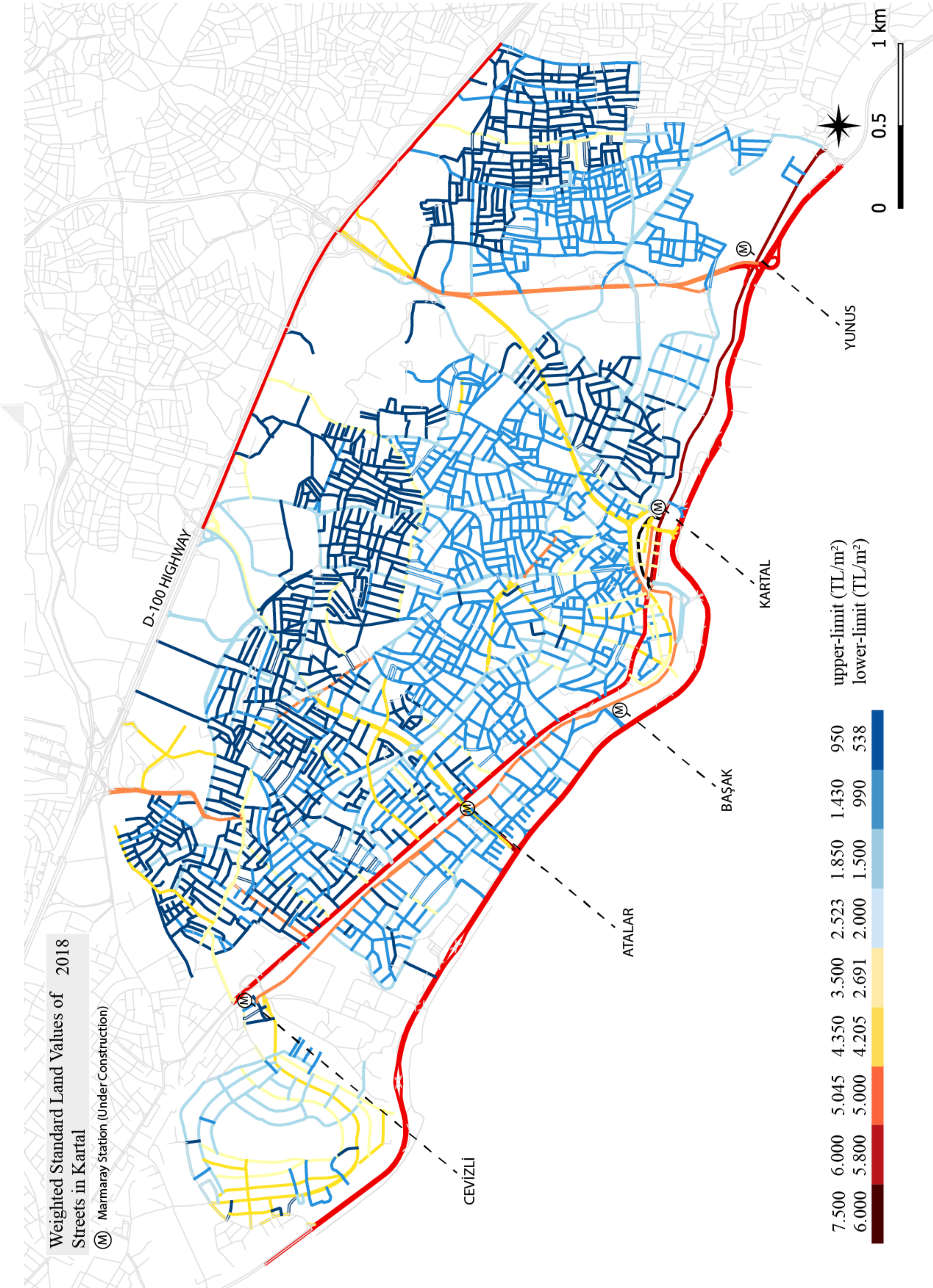
B.8.2.1 Weighted Standard Land Values of Streets – 2010



B.8.2.2 Weighted Standard Land Values of Streets – 2014

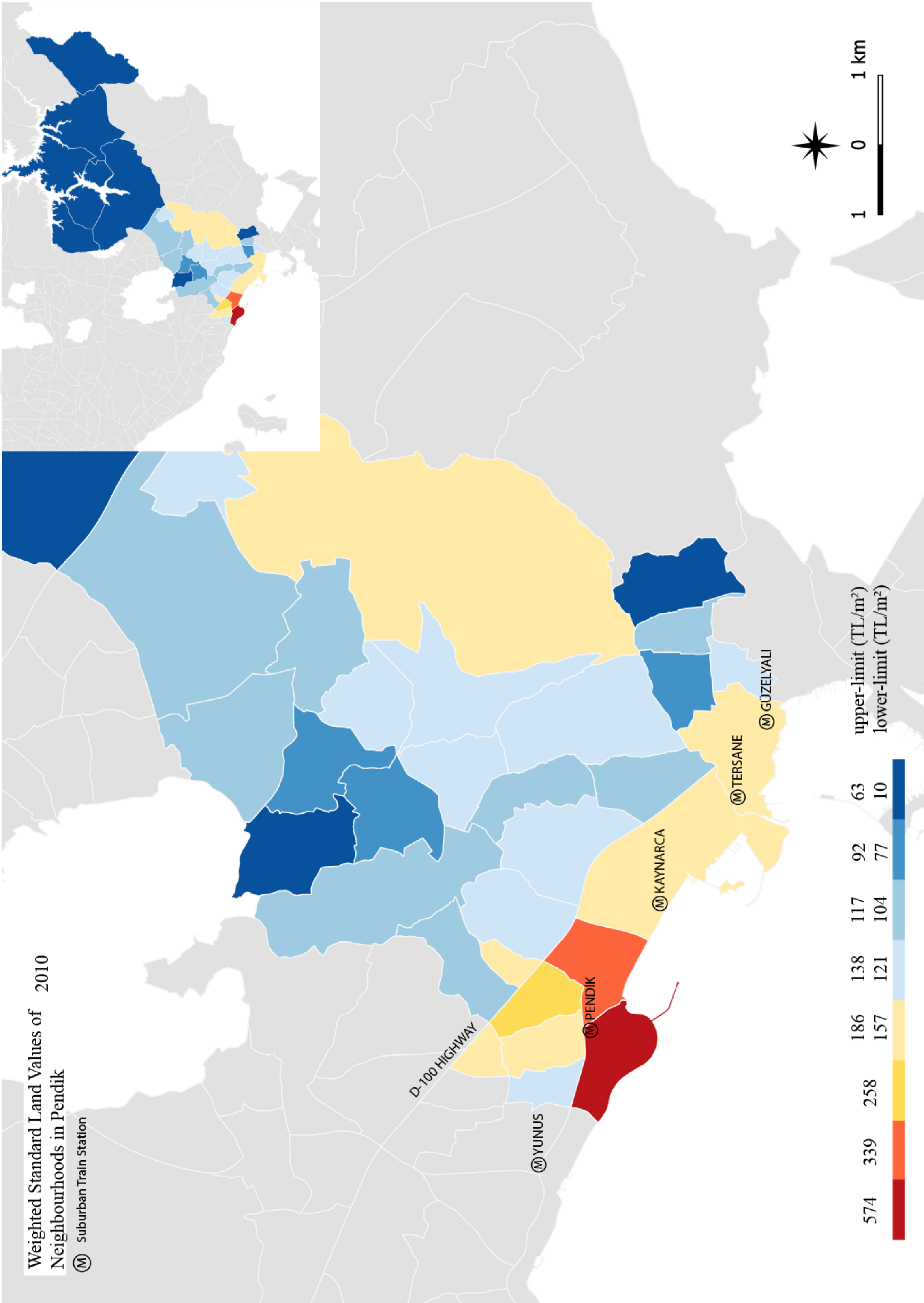


B.8.2.3 Weighted Standard Land Values of Streets – 2018

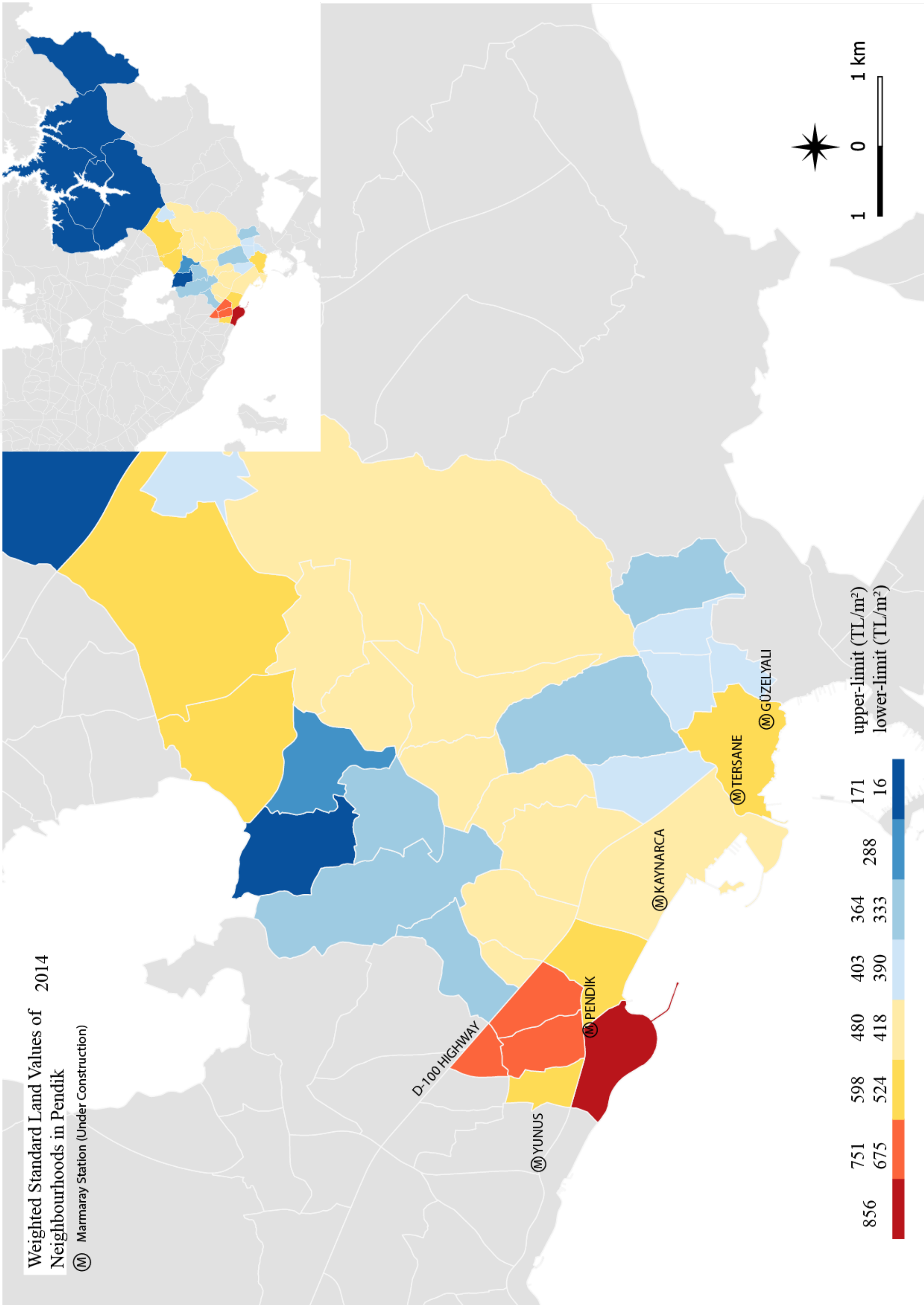


B.9 PENDİK

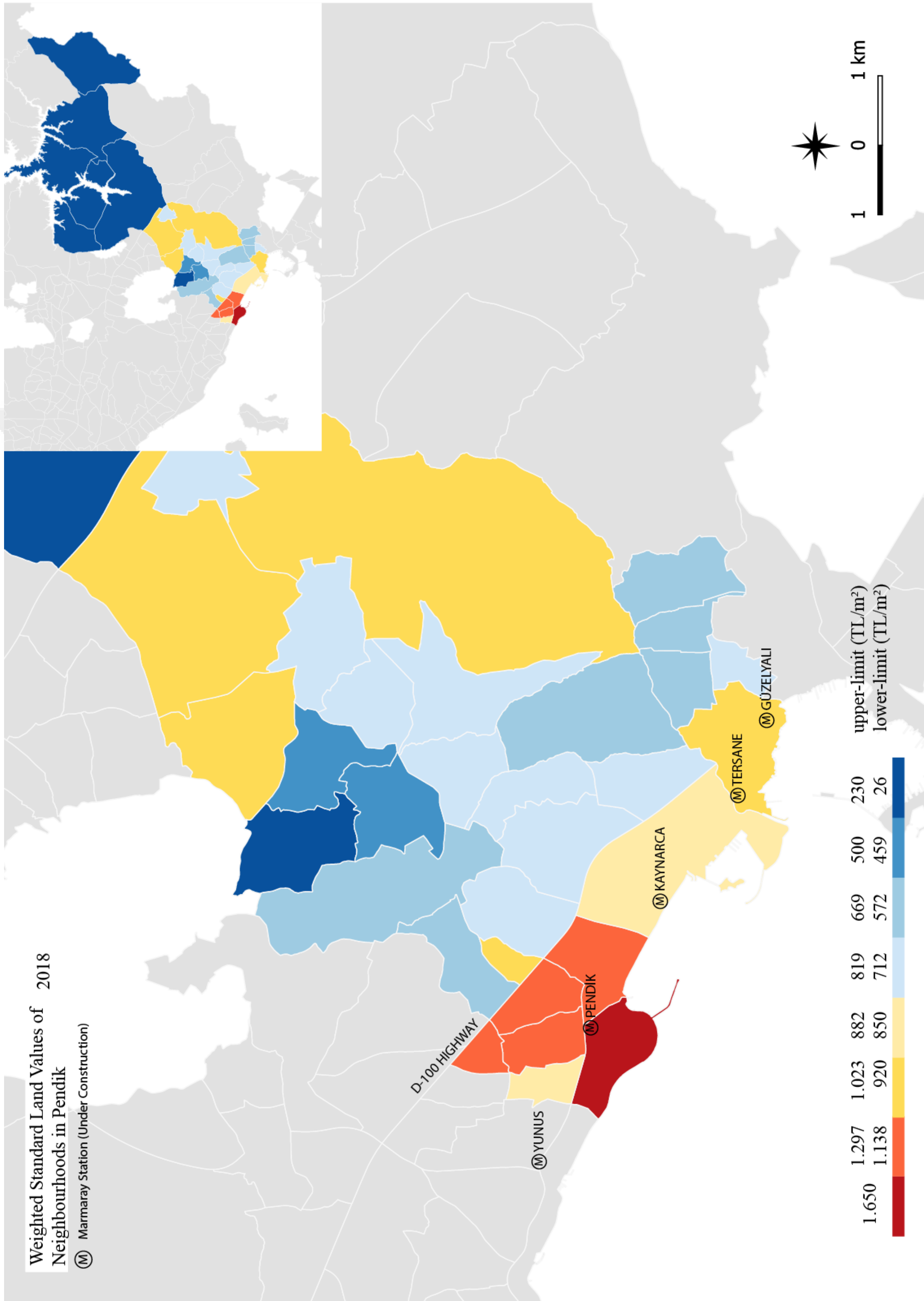
B.9.1.1 Weighted Average Standard Land Values of Neighbourhoods – 2010



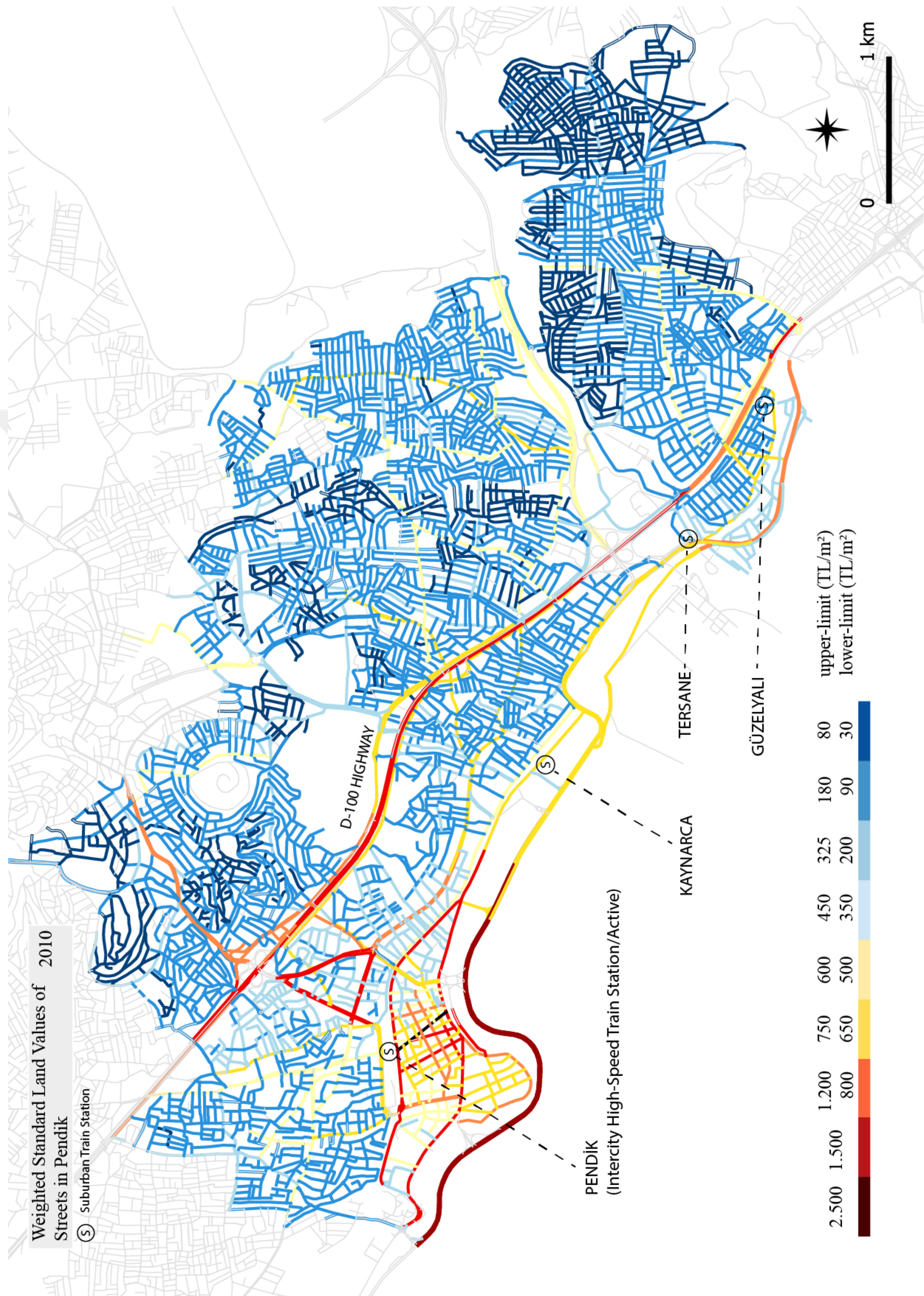
B.9.1.2 Weighted Average Standard Land Values of Neighbourhoods – 2014



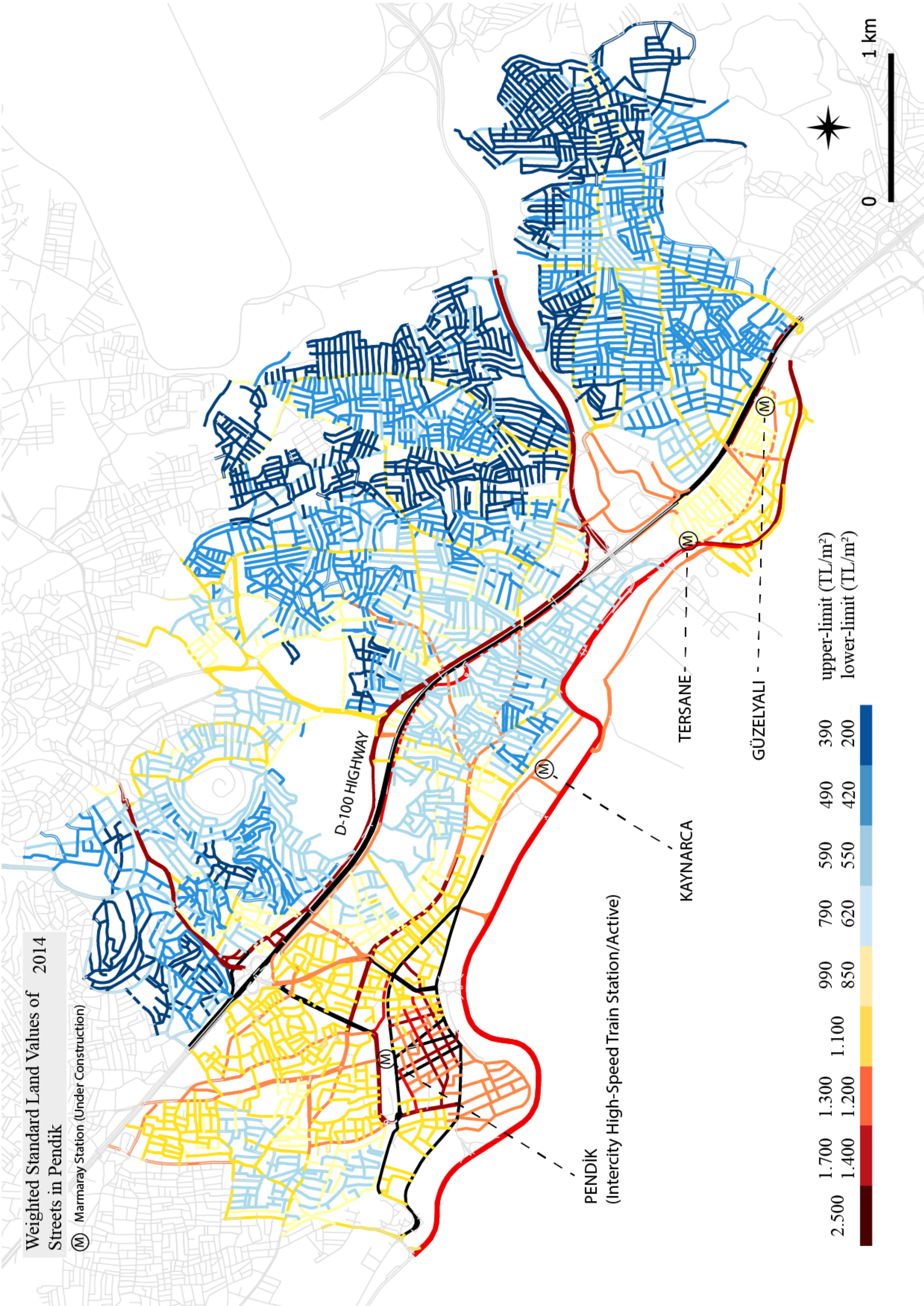
B.9.1.3 Weighted Average Standard Land Values of Neighbourhoods – 2018



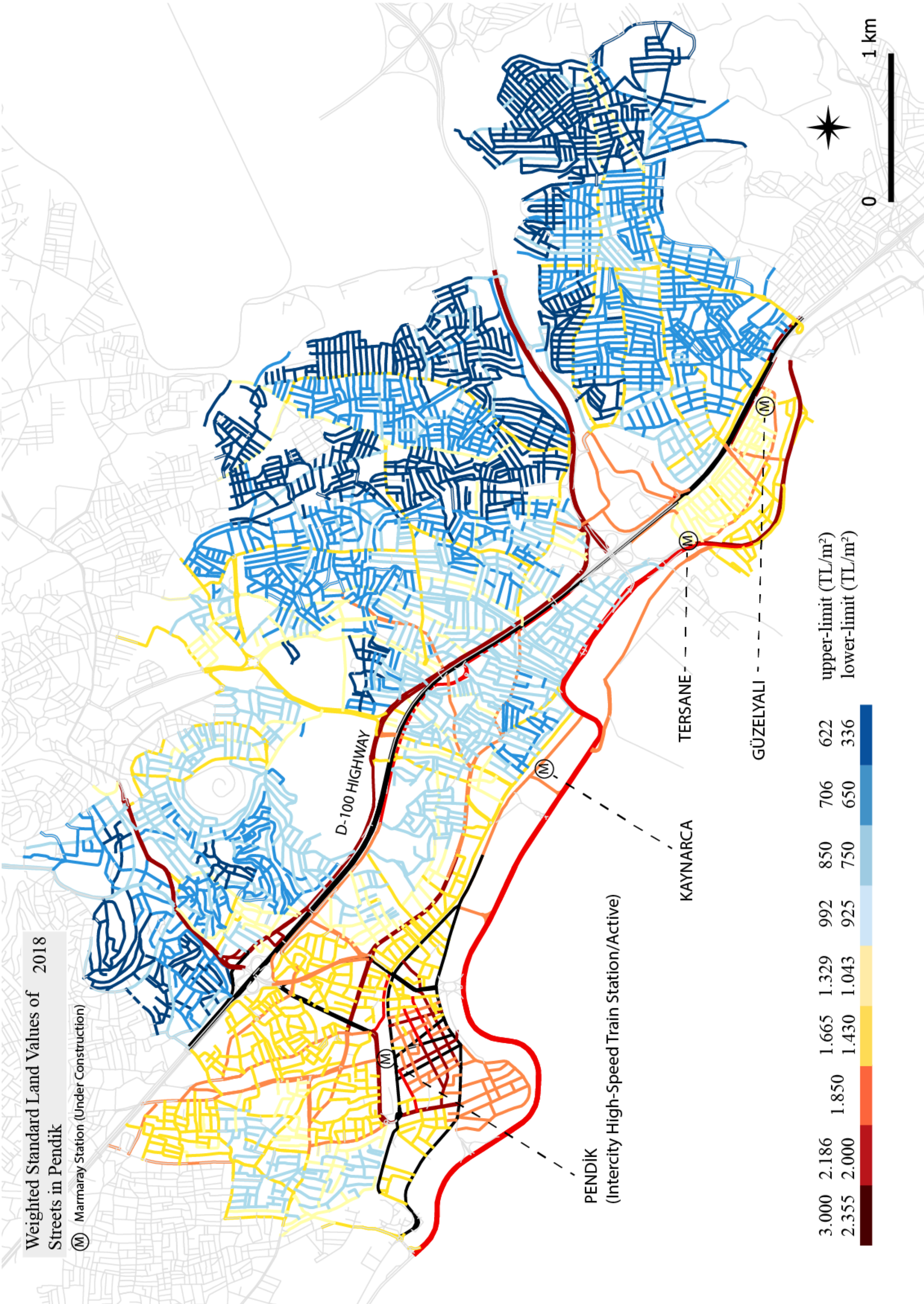
B.9.2.1 Weighted Standard Land Values of Streets – 2010



B.9.2.2 Weighted Standard Land Values of Streets – 2014

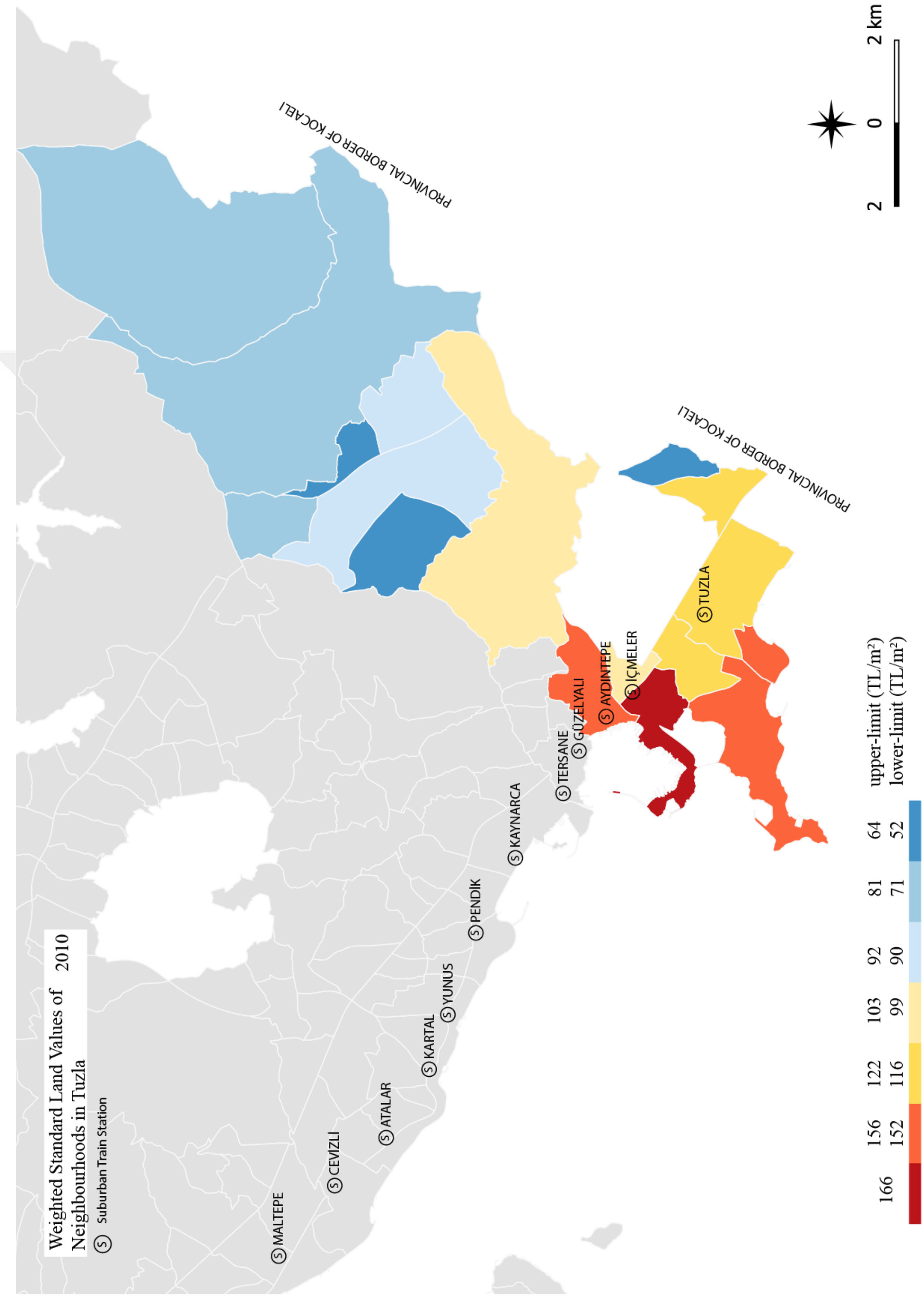


B.9.2.3 Weighted Standard Land Values of Streets – 2018



B.10 TUZLA

B.10.1.1 Weighted Average Standard Land Values of Neighbourhoods – 2010



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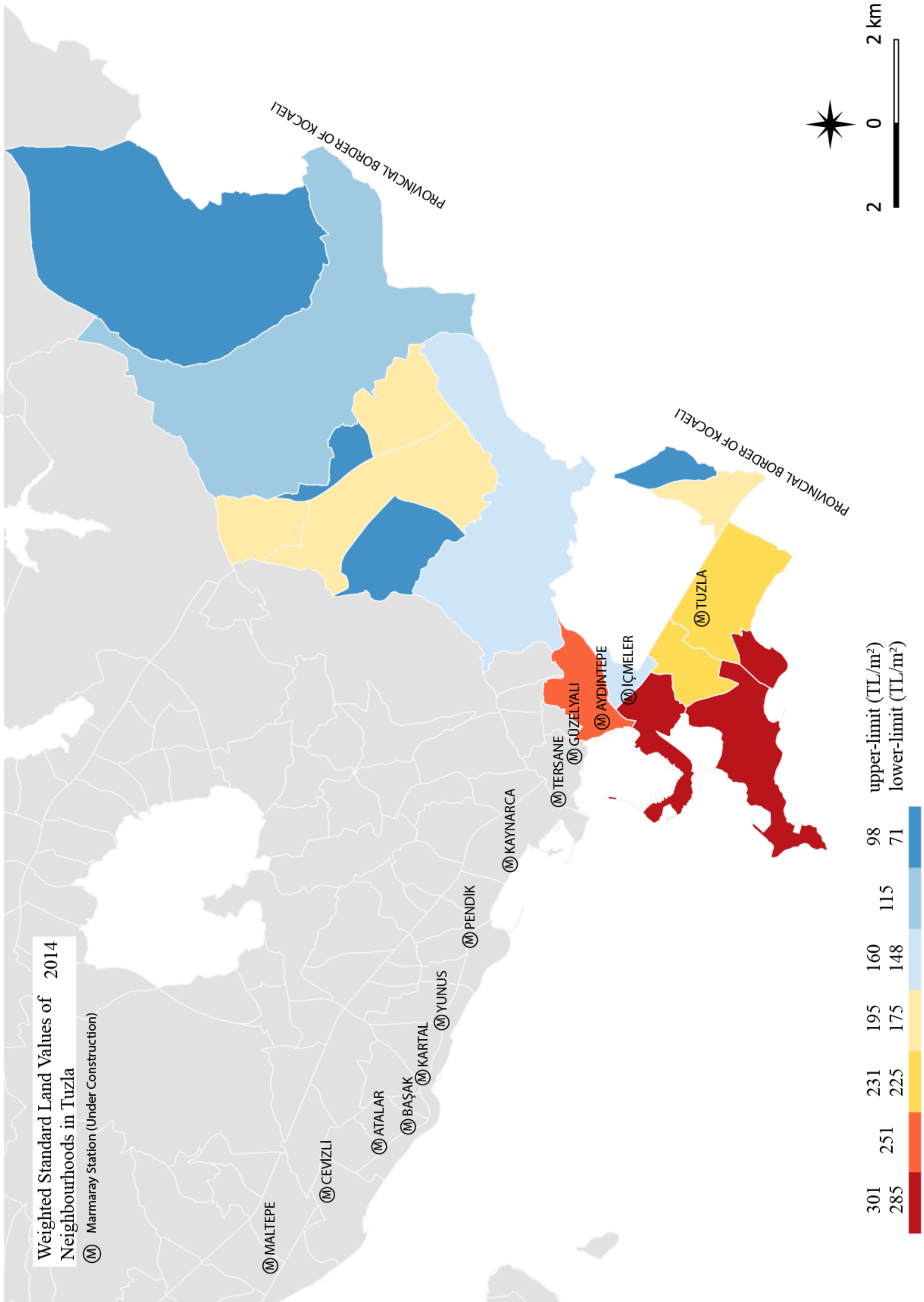

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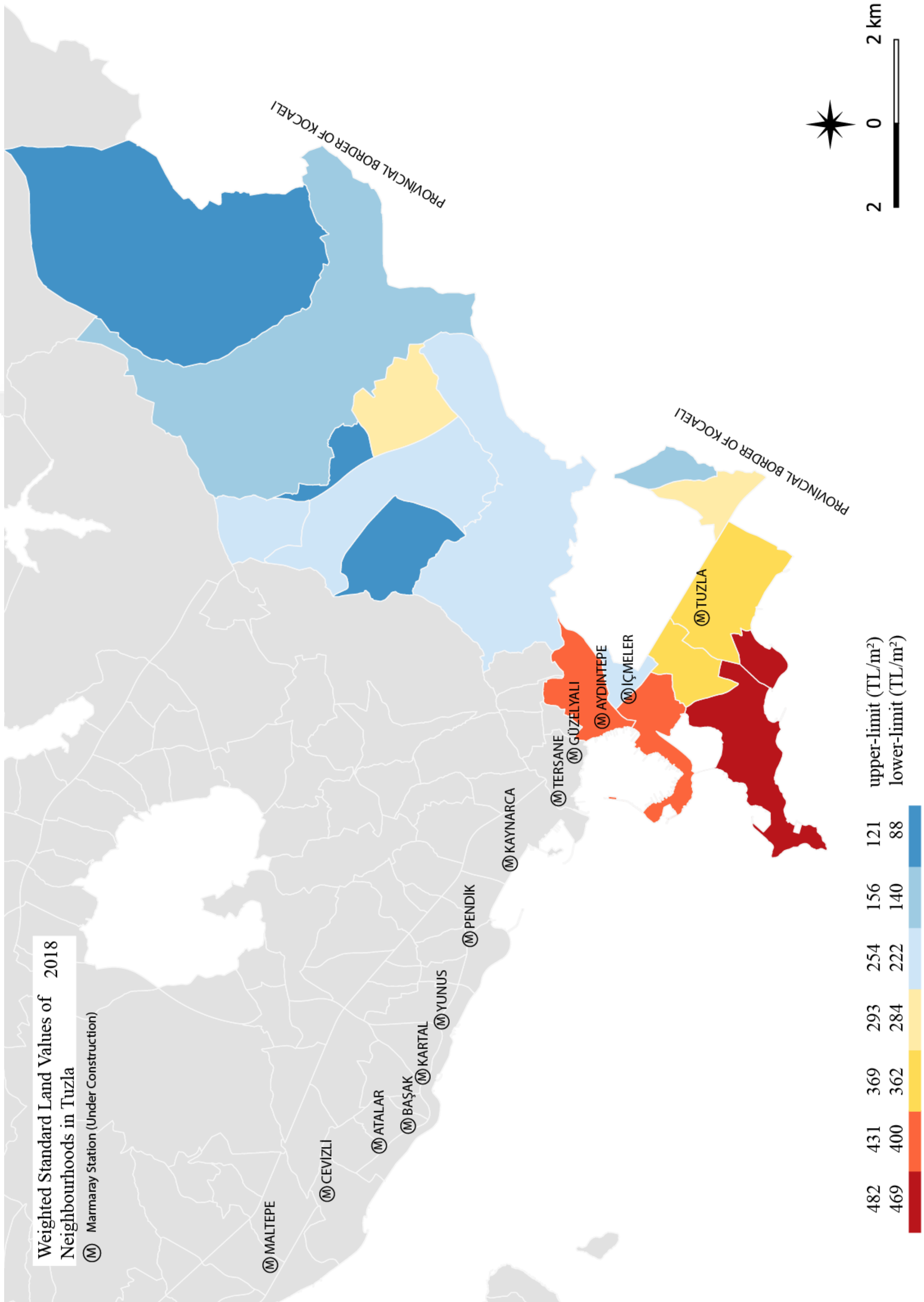

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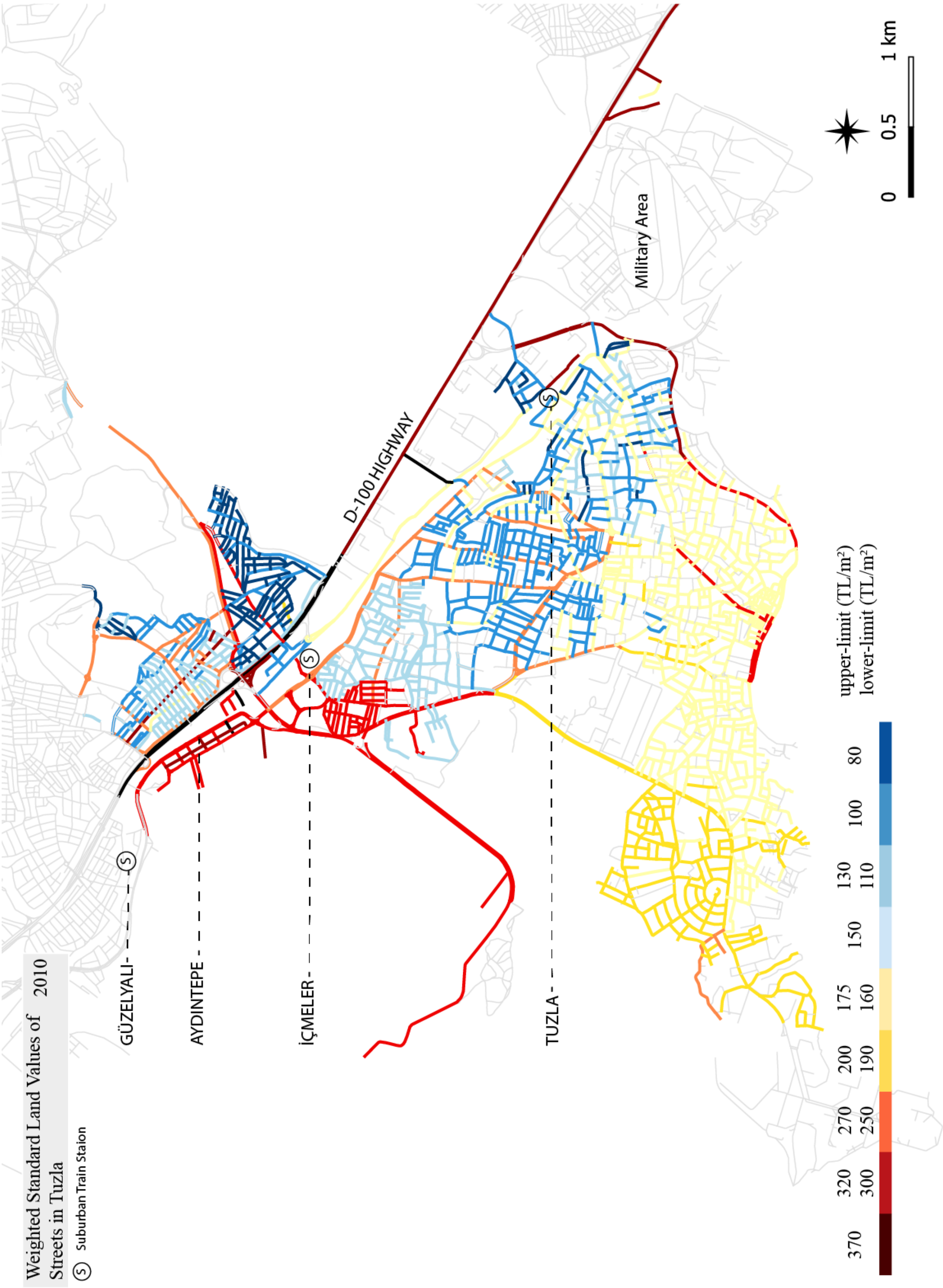

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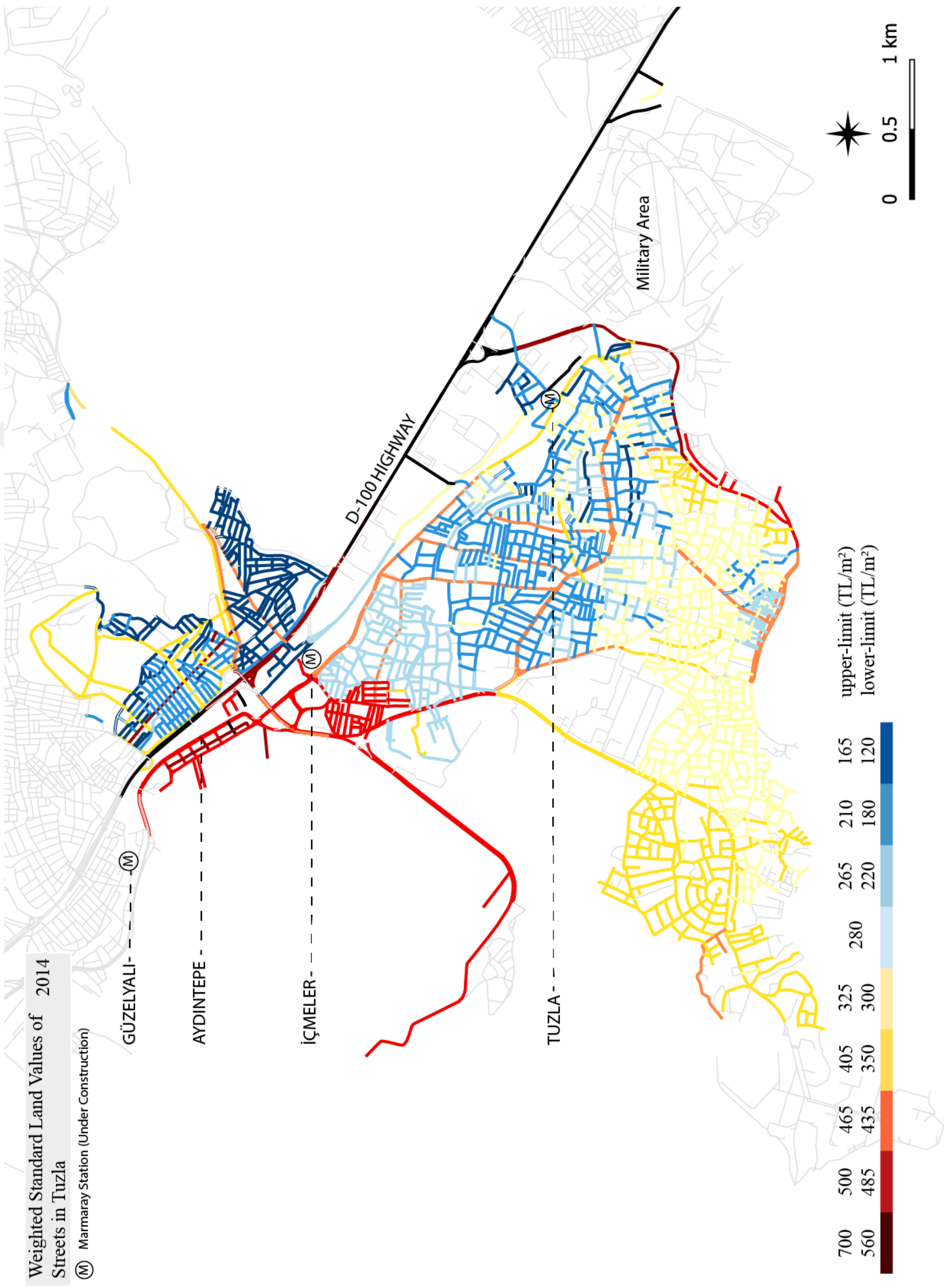
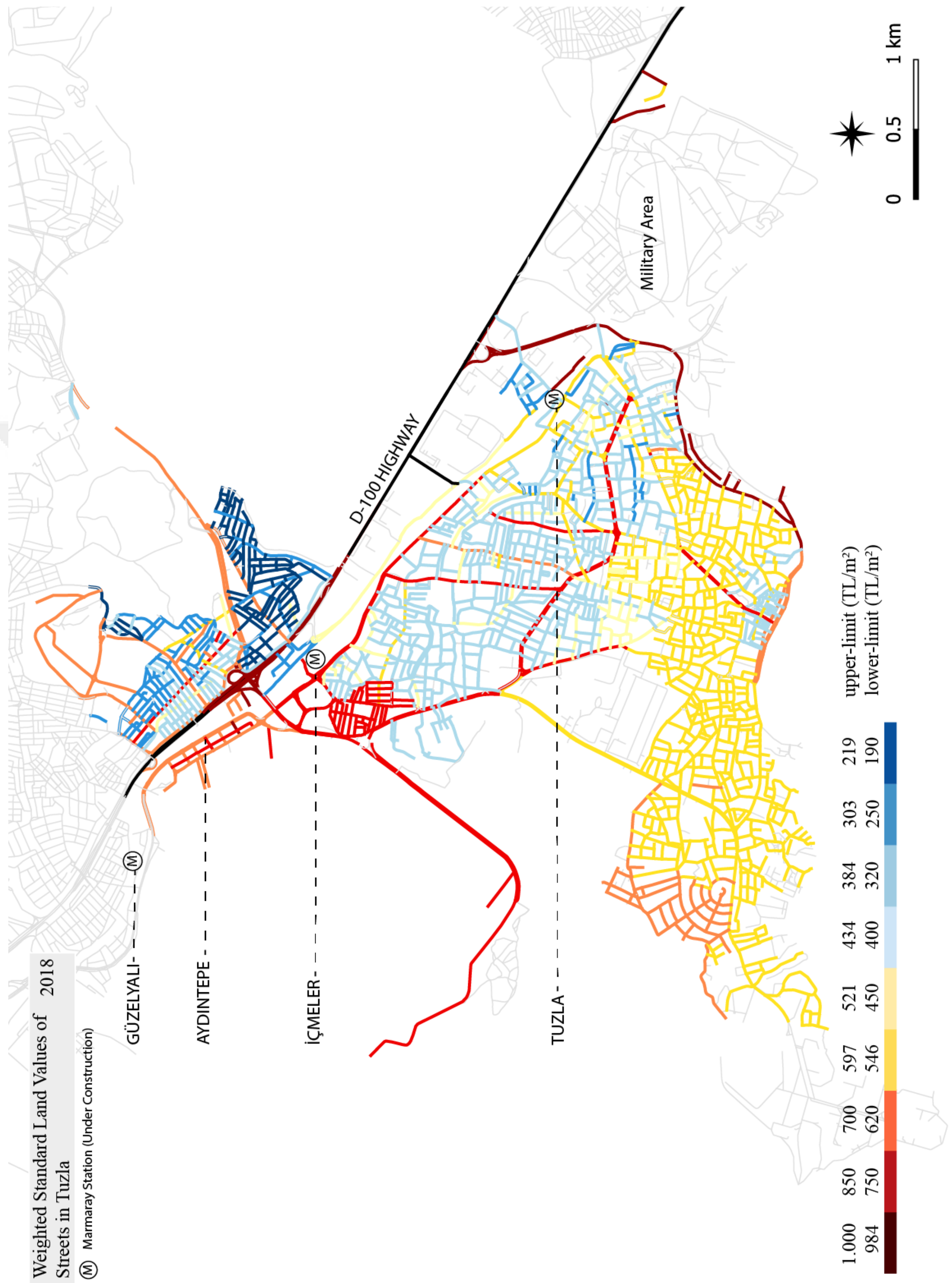
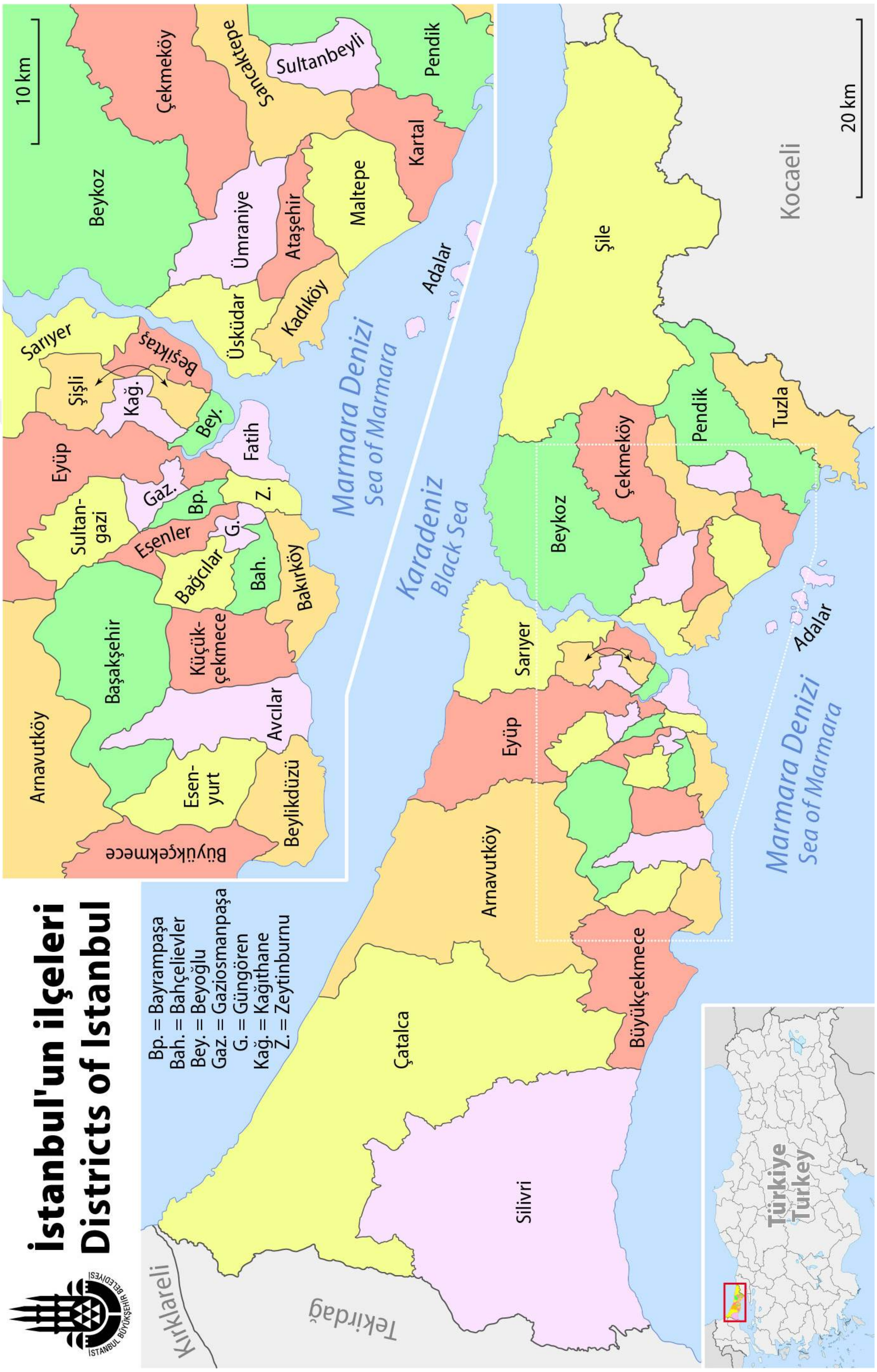


B.10.2.3 Weighted Standard Land Values of Streets – 2018



APPENDIX C : DISTRICTS OF ISTANBUL (Istanbul Metropolitan Municipality)



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Sarıoğlu Erdoğdu, G. P., Diker, B. and Orhan, C. (eds) (2018) *Fikirtepe'yi Sevmek Kentsel Dönüşümü Yeniden Düşünmek*. LAP LAMBERT.

Conference Papers

Orhan, C. and Sarıoğlu Erdoğdu, G. P. (2019) '*Mapping the Urban Transformation in İstanbul: Gaziosmanpaşa and Eyüpsultan Districts*', in Öztürk, P. Ç. and Osmanoğlu, E. (eds) 4th International Conference on Urban Studies: Economy and Urbanization. October, 16-18/2019. Ankara: İdealkent Yayınları, pp. 493–513. Available at: http://kentarastirmalari.org/icus2019/kongre_bildirisi.pdf.

AWARDS, PRIZES AND HONOURS

2020 **Master Thesis Financial Support**
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