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Spatial Integration and Accessibility Considering Urban Sustainability Patterns: Historical Islands of Istanbul

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Abstract

This paper aims to examine to understand the determinant factors on Istanbul Princes' Islands, based on the sustainable urban patterns as (1) Axial Analysis, (2) Segment Analysis, and (3) Correlation Analysis; which are mostly considered with the traditional accessibility measures of Space Syntax method.

Theoretically, the integration measure shows the cognitive complexity of reaching a street, and promises to 'predict' the pedestrian use of a street. This paper will consider the most and the least integrated areas of land use analysis concentrated on the location, size and type of different land uses; including the attractions in buildings. Terrain slope is also an important factor to evaluate how walkable for islands to see how walkable these islands are. Segment angular analyses have been done in different meters. These measures visualize angular integration at radius 400-1000 meters, which refers to the linearity of each segment in relation to all other segments within these meters. As for the result of footway quality, accessibility to and within these islands have been measured to understand and compare accessibility measures.
Keywords: Sustainable city, Prince Islands (Istanbul), Accessibility, Space Syntax.

1 Introduction

When we take a look at the urban areas from an accessibility frame, there are many studies to consider. Different approaches for understanding the urban

areas, some dimensions such as availability of public spaces, walkability and livability must be taken into consideration while these researches are being carried out. According to Lynch [1], environmental quality depends on 'attractiveness' which underlies the identity of space. These attractive points, nodes, landmarks etc. are based on pedestrian accessibility which can be noticed only on foot.

Accessibility is related with pedestrian movement. All direct relations, activities such as trade, social integrations or architectural awareness exist on streets. That's why the quality of architecture and public spaces of urban areas take a major role to sustain the accessibility of pedestrians, and thus the settlement itself. Public areas act as important venues to combine areas both in economic and social context. When we especially start to talk about the touristic parts of the town, ecological, economic and cultural effects take an important role to provide sustainability of space. Therefore, the quality of green and public spaces improves economy. In this case, public spaces are the generators of social relationships where streets are highly integrated with each other. But the question here is 'Should the highly integrated streets have a land use priority?' As it is known from Syntax Theory, the Walkability Index clearly indicates that the locations and densities of land uses have an effect on movement [2]. But, at the same time the crucial approach for human behavior experience, the index also proposes that "movement is more influenced by 'attraction or configuration of space" [2].

The study areas are Princes' Islands of Istanbul, which have been considered as an ideal space due to their historical layouts and the presence of a wide variety of typology of streets and surroundings. Considering the previously mentioned points, the environmental quality of the accessibility to the public spaces is analyzed through different factors of morphologic and functional dimensions involved in pedestrian accessibility.

The assessment of the morphologic dimension on these Islands would offer some important hints about the pedestrian accessibility measures in urban public. The Integration Analyses will be the key phenomena to understand the basics of the movement patterns which are the Space Syntax methods developed in 70's by Hillier and Hanson in 1984 **[3].** However, we want to clarify that, though this research follows the typical methods of Space Syntax Theory, it also tries to understand the environmental quality effects in rural like Princes' Islands, which provide sustainable urban areas.

2 Concepts and Method

This research is based on two fundamental ideas, the accessibility and morphologic approaches to space. Spatial integration accessibility uses a spatial representation called axial line and on the topological distance between axial lines are based on the number of steps. These steps are formed from one line to the other by the junction of the axial line and the metric radii will differ by routes and the trips' destinations [4].

This research project undertakes the potential movement as a prediction of travel distribution to some important nodes regarding the slope of the streets which really have impacts on spatial analyses.
Morphological approach is a spatial configuration type which plays a principle role for pedestrian mobility [5]. Pedestrians make their decisions of their routes within the spatial configuration of streets. The influence of spatial configuration on pedestrian movement is commonly understood as natural movement" [5]. Space Syntax theory proposes the integration measures, which means that pedestrian movement is dense or segregated, with respect to total (local integration) or whole (global integration).

The main phenomenon of Space Syntax is integration. The changes of the directions of axial lines need to be drawn from all public spaces in the system. That is why in Space Syntax concept the term 'depth' is used, rather than 'distance' which shows that integration measures are syntactic, not metric. Each and every line has a unique depth to all lines in the system which is correlated to accessibility pattern. The method that we want to present in this paper is based on the performing integration measures which are correlated with the pedestrian accessibility in Prince' Islands.

Axial lines are shown to work as the network unit for space syntax analysis through the years across diverse applications. The axial line has been shown to produce a specific representation of the city that is closer to the cognition and respresentation that people use to navigate [6,7].

Three data sets for segment analysis were analyzed in Depthmap. In order to clarify the walkability distances in the several meters of angular segments, analyses were carried out at radii 400 and 1000 m.

The expected results of these analyses will show how much the integrated areas are linked with the town centers and whether there is a correlation between topology/land use and accessibility in these kinds of rural areas.

3 Case Study

This research has been developed over the morphological and topological layouts of Princes' Islands of Istanbul and their open spaces such as streets, squares, gardens, parks etc. (Figure 1).

The name of the islands comes from the Byzantine period, when royal princes and empresses were exiled there. With the introduction of steamboats during the late Ottoman period around the 19th century, these islands became popular resorts for the elite who built their wooden houses. Jewish, Greek and Armenian communities were a majority of inhabitants here. Today, the islands are popular tourist destinations for daily excursions especially in the summer time. There are many monasteries and historic buildings on the islands besides 19th century Victorian style old wooden mansions.

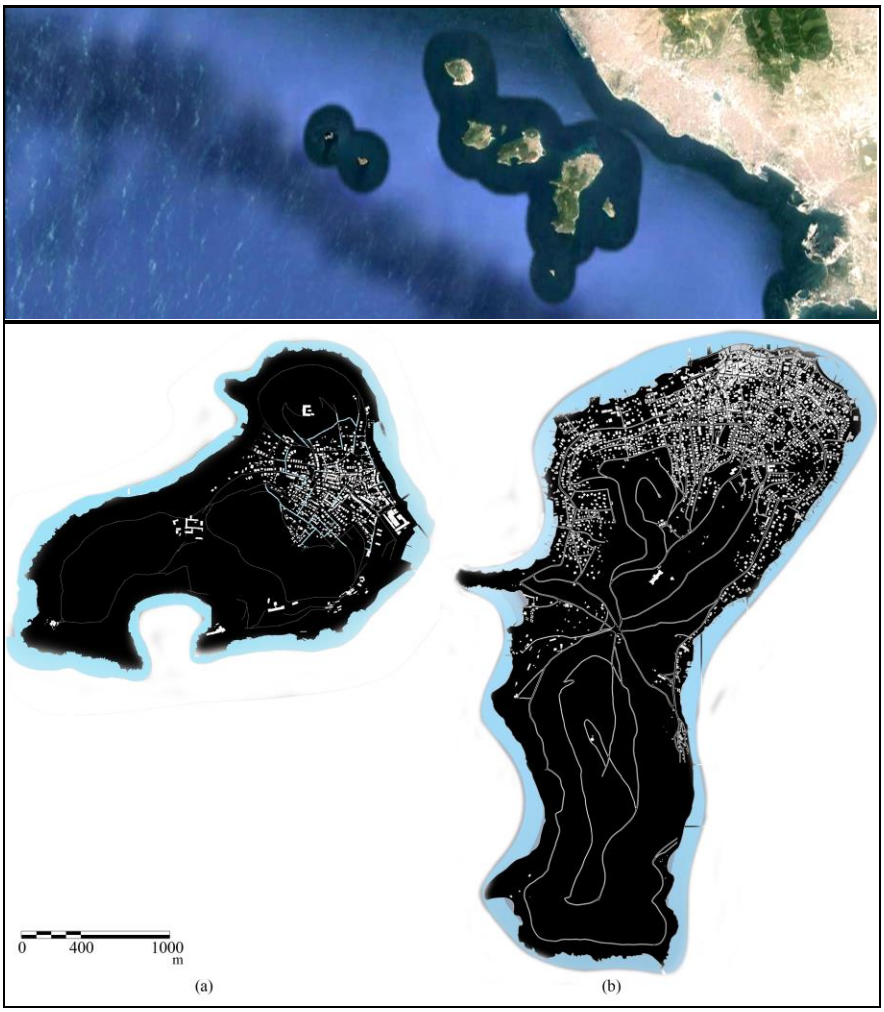


Figure 1: Aerial view of the Prince Island's (upper image) [8], Solid-void analysis: (a) Heybeliada, (b) Buyukada (below image).

3.1 Heybeliada

Heybeliada is the second largest of the Princes' Islands in the Marmara Sea near Istanbul (Figure 2). It has a length of 2.7 km from north to south and a width of 1.2 km from east to west. Heybeliada was known as "Demonisos" or "Chalki" in the past.

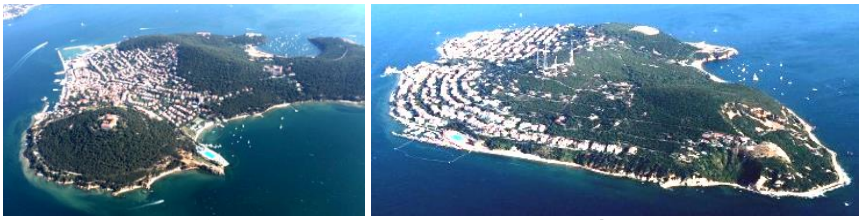
Heybeliada, located in the center of the Princes' Islands with three monasteries was a traditional fishing town until the beginning of nineteenth century. The population of the island grew steadily from 800 to 2,000 with the introduction of steamboat services in 1846. A Greek Orthodox Monastery (the main Greek Orthodox School in Turkey), the Elen Trade School (the first private

trade school in Turkey), and the Naval Cadet School have undoubtedly played an active role in stimulating the economic, social, and cultural developments on the island. With the initiation of steamboat services to Heybeliada, Visitors from the mainland frequented the island. have also developed an interest in visiting the island [9].

3.2 Buyukada

Being four kilometers away from the Anatolian shore, Buyukada is the largest island having two hills. The northern hill called İsa Tepesi (Hristos Hill) is 164 meters high, while the southern one called Yuce Tepe (Ayios Yeoryios Hill) reaches 202 meters (Figure 2).

The hotels, restaurants, beaches and mansions with flowered gardens housing social events attract visitors. Popular touristic activities include touring with donkeys and horse carriages within the island, sailing around the islands by motorboats visiting Dil Yorukali beach, Guvercin cave, Tavsan and Sedef islands, tracking, bicycling and visiting religious places. The activities and social gatherings are mostly organized in the popular hotels and clubs located in two promenade streets; which are named Yirmiuc Nisan and Cankaya [10].



(a) (b)

Figure 2: (a) Heybeliada aerial view, (b) Buyukada aerial view [11]

3.3 Axial Analysis

Axial maps are the representations and analyses of a system. Axial lines are the straight lines (sight lines) which pass from each public space. A single axial line means “a straight road” but when the road becomes curvilinear, more than one axial line is needed to represent it (Figure 3). Yet, an important point must be made here; axial lines create two-dimensional maps as if there are no height changes between the roads. So, in such places like Princes’ Islands, where topography shows different levels all around, we need more data to include in these analyses to understand the movement effects.

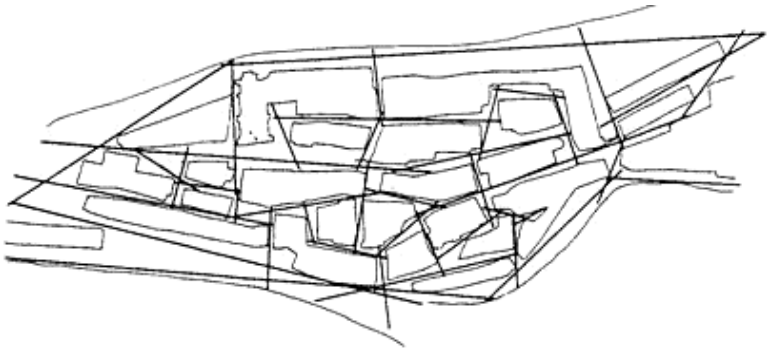


Figure 3: An axial map for Gassin generated via drawing the longest possible lines through the settlement's public spaces [3].

Integration analyses are based on axial maps. More the axial lines intersect, more they integrate. In other words; the street segments with fewest turns to reach all other segments in the system is called '*most integrated*'. Graphically, ones represented with hot colors are for the integrated spaces while the ones represented with cold colors are for the segregated spaces. Theoretically integration measure is often argued by the prediction of movement capacity.

According to the local and the global integration values in Heybeliada, the results show the widest road, Refah Sehitleri Street and some streets that intersect has the highest value which connects the curved paths up through the higher levels (Figure 4). This value explains the pedestrians within a local scale, which is called as natural movement. Moreover, for the land use patterns (Figure 5), this street has commercial activities which have an important role for pedestrian movement.

Focusing into Buyukada, Cinar Street can be seen as the most integrated street overall the island (Figure 6). According to the local and the global integration values in Buyukada, the results show the widest road, Cinar Street and some streets that intersect has the highest value (Figure 7).

Both the islands have typical characteristics with their preserved green areas and architectural qualities which are under protection. That is the reason why streets are getting sparse and segregated from each other as moving far from the town center. These situations can be seen in Figures 4, 7 as the comparison of local and global integration.

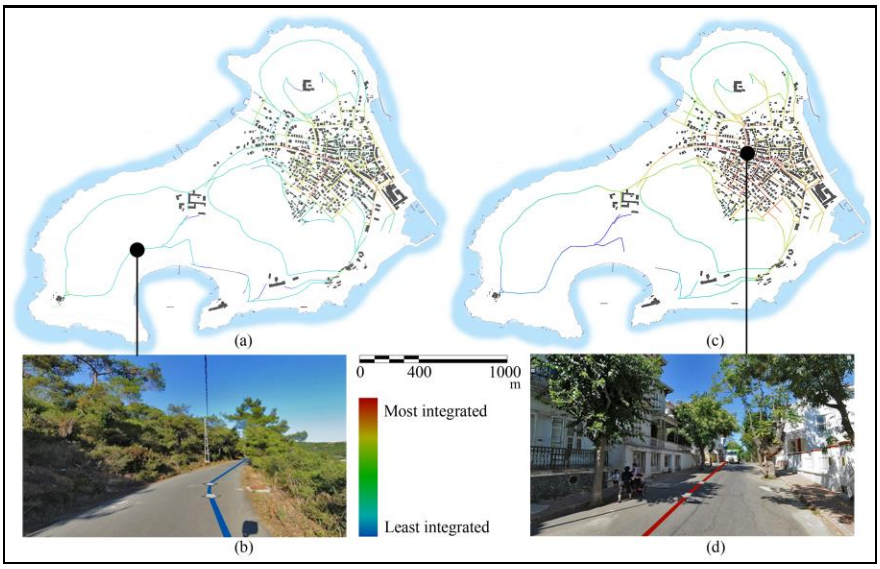


Figure 4: Integration Analysis of Heybeliada; (a) Local Integration Map HHR3, (b) Alp Gorungen Street: Least Integrated, (c) Global Integration Map HHRn, (d) Refah Sehitleri Street: Most Integrated.

Figure 5: Most integrated street land use of Heybeliada: Refah Sehitleri Street

Figure 6: Most integrated street land use of Buyukada: Cinar Street.

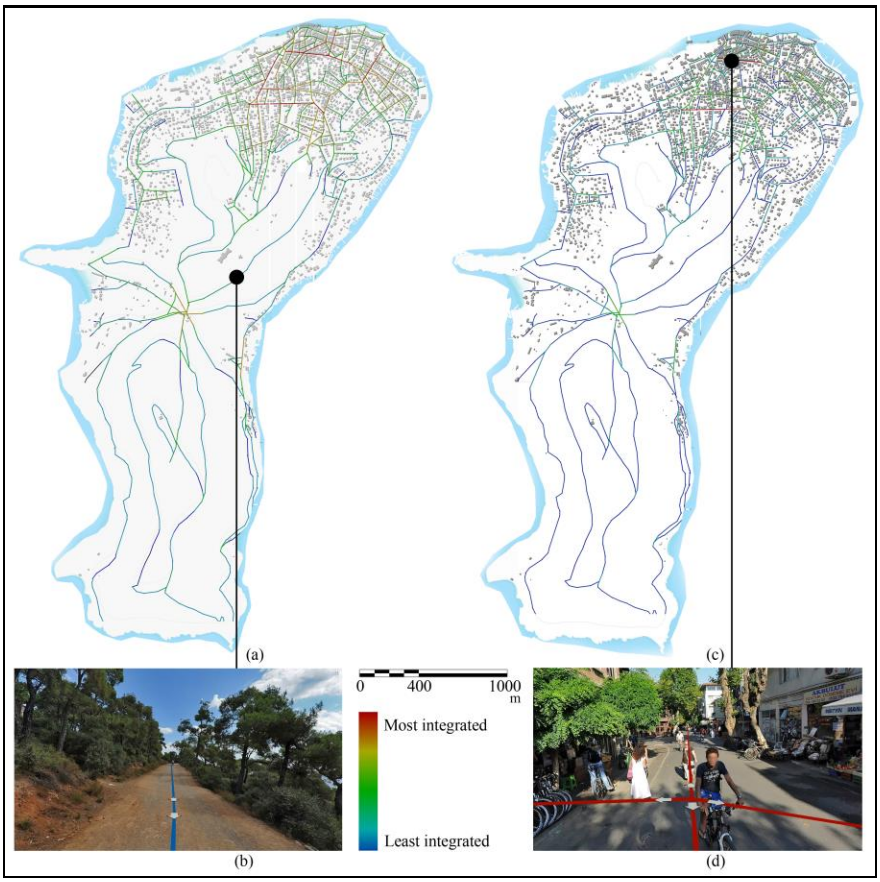


Figure 7: Integration Analysis of Buyukada; (a) Local Integration Map HHR3, (b) Nevruz Mevkii: Least Integrated, (c) Global Integration Map HHRn, (d) Cinar Street: Most Integrated.

3.4 Segment Analysis

Segment analysis is also based on axial lines like integration. In Segment Analysis, the basic spatial element is the straight line from one intersection/junction point to the next. The space syntax distance between intersecting elements (line-segments) are calculated in accordance with the angle between the lines. According to Raford et al. (2007) [12] space syntax analyses calculating "segment angular change" correspond well to bicycle traffic. More explicitly, it's generally believed that continuity in terms of "angular minimization" is essential for a good bicycle route [13].

The default analysis in Dephtmap is '*Segment Angular Analysis*'. That means the units of analysis are street segments, 'distance' relation between them is the amount of angular change from one segment to the other. A straight connection between two segments is a 0-degree connection, and a series of 0-degree

connections will be a straight line. Thus, in a sense, the analysis studies the line structure. It is called as the least angle or geometrical analysis which can also be analyzed in Dephtmap [14]. This shows how people navigate in urban spaces.

Heybeliada and Buyukada, like other Princes' Islands, are car-free spaces in town's cores where all facilities, restaurants, trading and public buildings exist. That means walking away from the center through the margins, residential areas stand out where those streets are mostly used by domestics. So, it would be better to understand pedestrian access routes 400 and 1000 meters of segment analysis which are shown in Figures 8 and 9.

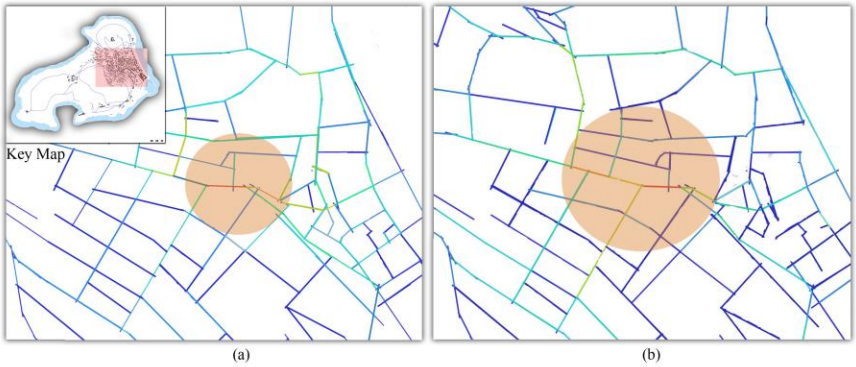


Figure 8: Heybeliada Segment Analysis, (a) 400 m., (b) 1000 m.

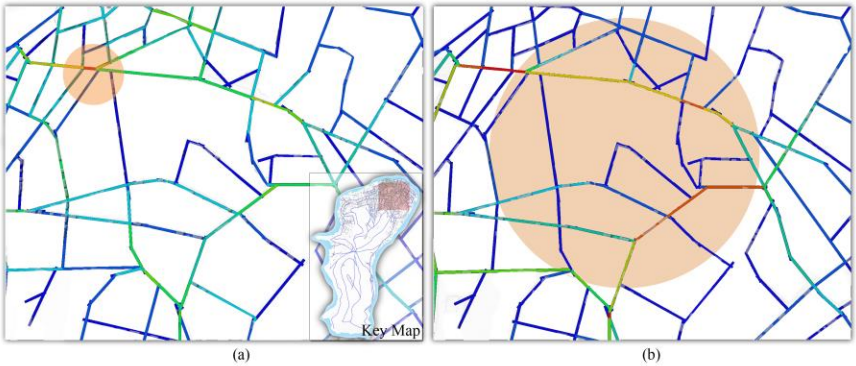


Figure 9: Buyukada Segment Analysis, (a) 400 m., (b) 1000 m.

3.5 Correlation Analysis

In order to understand the effects of slope differences on movement, correlation analyses have been done between global integration values and the percentage of streets slopes.

In Heybeliada, slope measures have been calculated within 200 streets and correlated with Rn measures (Figure 10). As a result, correlation coefficient is

r=-0.01004, which presents weak negative relations between them. In Table 1, some sample values are shown from these streets.

From the analyses, usually lower degree slopes reflected in the highly-integrated streets, and for the opposite, high degree of slopes in low integrated streets; explains the negative effect of correlation degree.

For example; in Nevicat street, slope is high as %15.46 and Rn is 0.676326 with high integration value as shown in Table 1. This street intersects with the most integrated street of Heybeliada and in the core of residential area. On the other hand, though Yali Rihtim Street has a very low slope as %0.03, its integration measure is found as a lower degree, as 0.448511 (Table 1). This street is much closer to the forest areas of the island with sparse housing.

Figure 10: Integration/slope relations of Nevicat street (left) and Yali Rihtim Street (right) of Heybeliada.

Among 110 streets of Buyukada, slope measures are calculated to correlate with Rn degree. Correlation measure is found as 0.08, which shows a relation between slope and movement patterns unlike Heybeliada (Table 1).

Cinar Street, which intersects with many streets in central Buyukada, has an intensive land use. It is 286.8 meters and the height difference between the west and the east sides of the street is 1.39, so the slope percentage is %0.48.

Carkifelek Street is 428 meters long and it is a wide street which contains a hospital zone. Not being as crowded as the Cinar Street, a large proportion of pedestrians use it (Figure 11). Height difference is 14.11 meters so the slope measure is %3.29. Considering the slope differences between the two streets; though the hospital exists in Carkifelek, it's not used as much as Cinar Street because of the slope effect.

Figure 11: Integration/slope relations of Carkifelek Street (left) and Cinar Street (right) of Buyukada.

Table 1: Integration/slope values of Heybeliada and Buyukada

	Integration value	Slope (%)	Correlation value		Integration value	Slope (%)	Correlation value
Heybeliada	0,67	15,46	r= -0,01	Buyukada	0,70	0,02	r=0,08
	0,65	0,36			0,67	0,90	
	0,64	12,32			0,60	0,03	
	0,64	3,98			0,60	3,29	
	0,52	3,93			0,57	0,48	
	0,45	13,15			0,57	3,40	
	0,45	0,03			0,56	5,97	
	0,41	6,11			0,56	5,80	
	0,38	34,93			0,48	8,55	
	0,32	8,69			0,40	6,47	

4 Results and Conclusion

The public spaces in both islands that were studied have the same extension and a similar service area. Heybeliada's town center is diffused and it prevents us to understand it clearly. Refah Sehitleri Street is long and wide enough to sustain more commercial facilities, but it cannot connect with shore side's partial streets. Compared to Buyukada, Heybeliada has more slopes,starting immediately from the shore; this reduces accessibility to small and diffused segments.

Nevertheless, Buyukada is more accessible than Heybeliada in terms of spatial configuration. Buyukada's town center is larger than Heybeliada; which means that it is surrounded by commercial areas and public spaces that serve sufficiently for both domestical and touristic use. Also, its central core is wide and the slope degrees are too low, which cause a better connectivity that increases the numbers of itineraries; a higher degree of local and global integration that collect pedestrian and bicycle flow through different levels of island space.

From here, there are some points which can be achieved;

- Regarding the slope and typology of space, locating commercial services in most appropriate places takes a crucial role.
- Considered traditional settlements especially in Istanbul are mostly sloped. While making analysis, a great amount of data should be included to correlate for better results. Because, one of the critiques of Space Syntax is that all paths/axes are weighted equally in the analysis. So, a street that has no buildings on is weighted equally with a street that has a number of tall buildings. In other words an area covered with residential land uses is weighted equally with an area full of commercial land uses.
- Princes' Islands are slow towns with green areas and light service systems which differentiate them from the city scape. Thus, while analyzing these kind of settlements; observing the society and their behavioral habits take a major role to understand the capacity and effect of space [15].

- Relations in public spaces provide integration by drawing the boundaries of social privacy [16]. It has been proved that Space Syntax is very useful in stakeholder negotiations since it can be trusted more than just an architect's or urban planner's experience or his/her intuition.

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