

# Towards sustainable transportation: identification of the spatial configuration of rental housing area using space syntax method

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**Abstract.** The emergence of several higher education infrastructures in Bandung city caused the significant increase of inhabitants in the certain region. This resulting in the fast growth of rental housing, while the region's structure itself is mostly organic and having some cul-de-sac areas. This kind of structure is considered as unideal for a residential area in the context of public transportation accessibility. Based on that, this study aimed to identify the structure of a rental housing complex in Bandung regarding its accessibility for public transport, using space syntax method. There were three main findings revealed from this study. The most segregated area was also the least integrated. There was a significant range of spatial hierarchy between the shallowest and the deepest area. There was an only small area in the case study that considered as accessible regarding the distance to public transport. This condition may lead to certain urban problems such as traffic congestion or excessive fossil fuel usage. These findings could act as a suggestion to the government for policy regarding the regulation for rental housing areas in order to minimize the growth rate of private vehicle possession so as to support the development of sustainable transportation of a city.

## 1. Introduction

Before impacted by urbanization, housing in most area in northern Bandung were commonly occupied for family living. But nowadays, as several universities like UNIKOM, ITB, UNPAR, UNPAD started to occupy this area, the houses were affected accordingly. Several houses that used to be a regular housing for family has now became a rental housing. Thus, it increased the inhabitant's population while there is no significant adaptation from the existing structure of the region.

This densification also affecting its transportation needs. By the time a population of a city become denser, there is another issues aroused which is transportation. As a result, accessibilities to public transportation became an issue for the housing area, especially those with a high density population such as rental housing. Accessibility from a housing area to public transportation is now becoming more important considering its impact to the inhabitant's willingness to use public transportation [1] as an attempt to reduce the city's traffic congestion. While at the same time, the housing structure itself should meet the criteria of walk for transport.



Space syntax, as an analysis tools, is having an ability to identify social phenomena in a built environment such as accessibility by examining its spatial configuration. This research used Tubagus Ismail region in Bandung as a study case since this region is meeting the criteria of the above described phenomena such as rental housing area, density, and accessibility. Tubagus Ismail is a sample of housing region that previously was built as regular housing which at certain period undergone a transformation to be a rental housing.

The aim of this research is to identify the spatial configuration of Tubagus Ismail as a rental housing region and its relation with its accessibility to nearest public transportation transit.

## 2. Literature Review

### 2.1. *Space Syntax*

Space syntax is a set of tools to represent, quantify, and interpret a spatial configuration in a building, city, interior, or landscape [2, 3]. The main focus of space syntax is the relationship between human and the space being occupied. This theory is based on a characteristics that uniquely presented in a society inside a spatial system, and the knowledge that adhere to this society is described through the space itself, as well as through the spatial configuration [2].

In its theory, the relation between the spaces is what considered as the spatial configuration while the idea about how specific form of a space could affects the behavior of its inhabitant is what considered as the social knowledge. The goal of space syntax research is to elaborate the social value from the configuration of the occupied space. This could be used to develop practical knowledge about the effect of particular space towards society with varied social or cultural variables. The basis of space syntax is to understand the configured space, specifically about the forming process and the social value [3]. In short, space syntax is an attempt to build a spatial configuration in architecture by producing theoretical understanding toward how human create as well as using spatial configuration. In other words, as a tool to identify how some spatial configuration could express the social and cultural value. And how this spatial configuration resulting a social interaction and built environment.

Several researches and publications proves that space syntax in the early period was focusing on a real world environment and had trying to identify the most basic attributes of built environment. By consistently developing the techniques for representing and analyzing spatial pattern, current space syntax research has reaching on an attempt to stimulate the spatial configuration of a design, as well as predicting the social pattern of the space being designed.

### 2.2. *Rental Housing Region*

Rental housing in this context is described as an informal rented house in Indonesia that commonly called as “Kost”. The difference between “Kost” and other rental housing facilities is that this type of rental housing come in various conditions and arrangements, so the tenants are provided with a lot of choices in the market that may suit their preferences, economic capabilities and cultural issues. In addition, a “Kost” tends to be paid on a monthly basis and has a flexible contract period [4].

Recently, there is no any housing public policy in Indonesia that specifically administering the rental housing region’s structure. The growth of such region are usually occurred in an organic way [5]. The morphology of this region are commonly started as a regular housing that transformed as a rental housing. Many of the housing areas in Bandung are having a structure that contains lot of intersections, narrow alleys, and cul-de-sac. These circumstances are what make the rental housing in Bandung, especially those in northern area, could be a unique region in terms of social characteristics related to its spatial configuration.

### 2.3. *Walk for Transports*

To reveal the properness of a certain region in terms of walk for transport, there should be a clear maximum standard distance requirement as the parameter. Walk distance is important because walk is the primary access mode for trips from home to public transport and because walking distance has a

significant impact on public transport use [6]. For this, there are several publications that had identify the maximum standard distance between a residential region and a public transportation transit point within the reach of walking activity.

There is a publication from Malaysia that successfully revealing the maximum distance of people in Malaysia in walk for transport which is 500 meter [1]. Another publication from Maryland, US has had identify the maximum distance of walk for transport as 400 meter which is roughly equal to 5 minutes walking [7]. In Helsinki, the maximum distance of walk for transport is 300 meter [8] while in Perth, Australia, the maximum number is same as in Malaysia, which is 500 meter [9].

The standard number revealed from those publications are certainly pretty much affected by the physiological condition of the inhabitants from each region. In addition, every region has its unique characteristics in terms of climate and landscape. While in this research, the location of case study and its inhabitant's characteristics are almost similar to those in Malaysia since both Malaysia and Indonesia are sharing the same climate and same physiology condition based on their race similarity as Melanesian. From that, 500 meter distance is determined as the standard of walk for transport in this research.

### 3. Method

#### 3.1. Data Collection Method

The region data used in this research is based on the 2015 AutoCAD photogrammetry map of Bandung city, while the mapping of rental housing unit location was based on field observation (Figure 1).



**Figure 1.** Location of rental housing units in Tubagus Ismail region.

#### 3.2. Analysis Method

Based on the convex map from the AutoCAD data, an axial map firstly had to be created as the basis for the next step of space syntax analysis. From this axial map, the syntax structure of the region was revealed topologically. Then, in order to analyze the accessibility of certain region, there were several steps should be undertaken in space syntax method. First, integration analysis should be done to classify some area with the highest and the lowest density of accessibility. Second, depth analysis should be done to classify the range and the variation of depth occurred in the study case region. Besides, this depth analysis was conducted to identify the level of accessibility to the nearest public transport transit area. Third, there was segment analysis in order to identify the quality of region's structure in terms of walk for transport accessibility using the previously mentioned standard as the benchmark. By using this segment analysis, any areas that meet the walk for transport standard distance and the areas that does not would be identified.

These series of steps in space syntax analysis was conducted by the assistance of space syntax software namely DepthMap developed by University of College London.

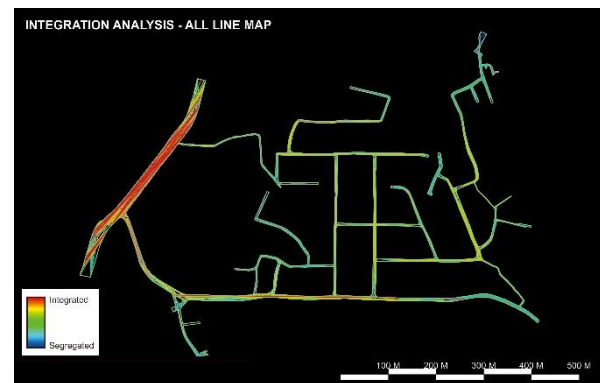
#### 4. Analysis

According to the map data obtained, firstly a convex map should be created as the boundary of the axial line going to be built (Figure 2). In this step, the convex map created was restricted only inside the Tubagus Ismail region and a big street namely Jalan Raya Juanda which was the nearest street to the Tubagus Ismail area that had a dense traffic of public transportation.

From this convex map, an axial line map could be then generated (Figure 3).



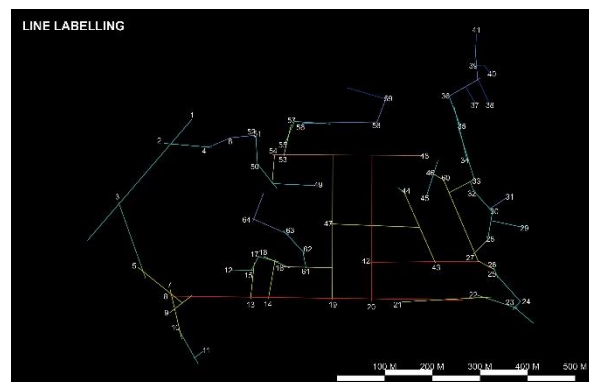
**Figure 2.** Convex map of Tubagus Ismail region.



**Figure 3.** Axial map result.

##### 4.1. Integration Analysis

This axial map was then reduced to be a more simplified version (Figure 4). This was due to facilitate a clear and easily quantified version of axial map. This simplified axial map was then used as the basis of integration analysis to identify the density of accessibility in this region in certain area.



**Figure 4.** Simplified axial line map result.

According to integration analysis, there were several areas detected as the most integrated and the most segregated. The red colour on the map was illustrating the integrated areas and blue colour was illustrating the segregated areas. Every single line on this map were then given reference number on each of them to ease the identification process. It was clear from the colours that the most segregated area were line number 59 and 41, while the most integrated area are line number 8, 20, and 42.

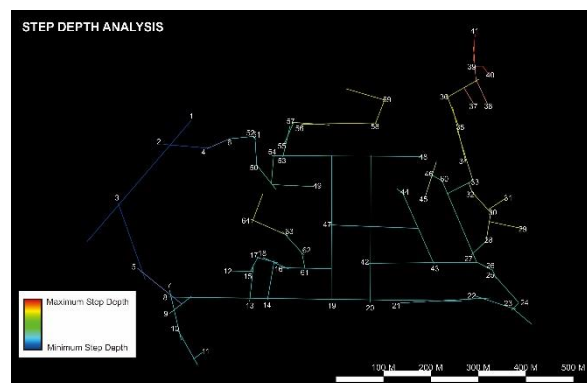
##### 4.2. Depth Analysis

According to the identified integration value, a depth analysis was then operated. This analysis require one line as the “root” to be the point where the other lines distance to it would be calculated. In this case, Jalan Raya Juanda (line 1) became the root. This depth analysis was more of a topological calculation rather than metrical. In determining the nearest access, depth analysis is pretty much

affected by the integration value which has defined previously. The higher the value of a line, the more this line is going to be chosen as the most accessible line during this depth analysis process.

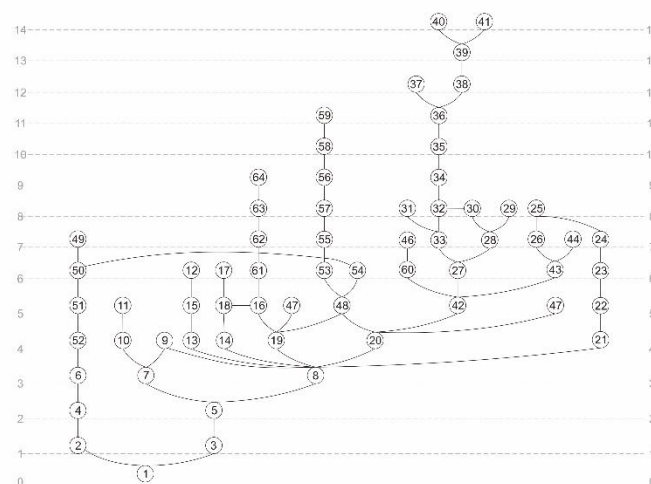
The characteristic of depth analysis is the higher the depth number of a line, the more inaccessible this line is. So as the opposite.

Through Figure 5, how the depth condition resulted from the Tubagus Ismail housing's structure was demonstrated. Blue line in Figure 5 is indicating the shallowest area, while the red is indicating the deepest area. From this analysis, it was found that line 40 and 41 were the deepest areas. But, if the line with the rental housing unit was included in this process, the deepest areas were on the line 59 and 35. This was due to the absence of rental housing units in line 40 and 41.



**Figure 5.** Depth analysis result.

According to the depth analysis, a justified permeability graph (JPG) was constructed. JPG is very useful to help identifying the range of depth occurred in this region. By identifying the range of depth, the hierarchy was then could be visualized (Figure 6).



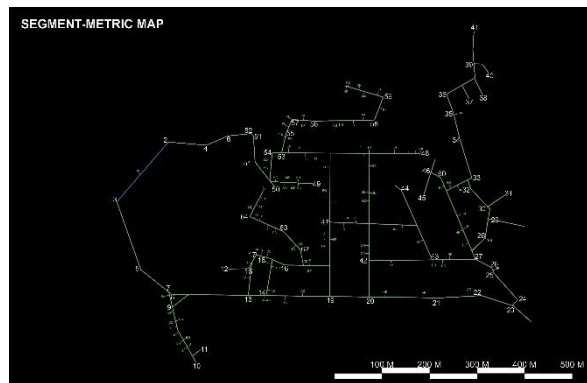
**Figure 6.** Justified permeability graph.

By examining the JPG, the range of depth hierarchy occurred in the whole region was revealed. The lines involved in this JPG construction were restricted only to those that occupied by the rental housing units. This region was proven to have 14 levels of depth hierarchy which was indicating a big gap of accessibility level throughout the Tubagus Ismail rental housing region.

#### 4.3. Segment analysis

Segment analysis was then conducted so that the metric distance of the axial line could be read clearly. This was due to identifying any areas of rental housing in the case study that meet the standard

distance of walk for transport and those which are not. In this case, line 1 (Jalan Raya Juanda) was still works as the root of the calculation. But this time, the calculation was done metrically, not topologically. For a detailed result, the distance calculation was operated using every single rental housing unit in the location as the starting point to reach the root line (Figure 7).



**Figure 7.** Segment-line map.

Through metric distance calculation on the segment-line map, by using the standard distance of walk for transport discussed earlier, there were some areas within the region that were considered as accessible and some that were not. In Table 1, the green coloured rows were indicating the rental house unit that meet the standard distance.

**Table 1.** Metric distance per housing unit.

Tubagus Ismail Raya				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	AA	8	3	421
2	AB	8	3	430
3	AC	8	3	466
4	AD	8	3	502
5	AE	8	3	675
6	AF	8	3	683
7	AG	21	4	778
Tubagus Ismail 1				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	BA	7	3	233
2	BB	7	3	269
3	BC	7	3	289
4	BD	7	3	289
5	BE	7	3	301
6	BF	10	4	313
7	BG	10	4	331
8	BH	10	4	333
9	BI	10	4	348
10	BJ	10	4	349
Tubagus Ismail 3				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	CA	14	4	445
2	CB	14	4	495
3	CC	14	4	500
4	CD	13	4	433
5	CE	15	5	464

Tubagus Ismail 4				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	DA	17	6	484
2	DB	17	6	494
3	DC	18	6	507
4	DD	16	5	592
5	DE	16	5	601
6	DF	16	5	600
Tubagus Ismail 5				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	EA	62	7	634
2	EB	62	7	631
3	EC	63	8	691
4	ED	63	8	708
5	EE	63	8	741
6	EF	63	8	730
7	EG	64	9	768
8	EH	64	9	780
9	EI	64	9	799
10	EJ	64	9	812
Tubagus Ismail 6				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	FA	19	4	666
2	FB	19	4	679
3	FC	19	4	678
4	FD	19	4	691
5	FE	19	4	756
6	FF	19	4	767



7	FG	19	4	782
8	FH	19	4	832
Tubagus Ismail 7				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	GA	20	4	651
2	GB	20	4	667
3	GC	20	4	761
4	GD	20	4	779
5	GE	20	4	777
6	GF	20	4	834
Tubagus Ismail 8				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	HA	42	5	806
2	HB	42	5	895
3	HC	42	5	915
4	HD	42	5	929
5	HE	60	6	1022
6	HF	25	8	1028
7	HG	27	6	1043
8	HH	60	6	1052
9	HI	60	6	1054
10	HJ	60	6	1084
11	HK	33	7	1167
12	HL	60	6	1153
13	HM	60	6	1153
14	HN	34	9	1325
Tubagus Ismail 9				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	IA	47	5	752
2	IB	47	5	762
3	IC	47	5	778
4	ID	47	5	860
5	IE	47	5	876
6	IF	47	5	871
Tubagus Ismail 12				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	JA	43	6	905
Tubagus Ismail 14				
No.	House	Line	Depth	Metric

	Unit	Number	Level	Distance (m)
1	KA	53	6	1006
2	KB	53	6	1008
3	KC	55	7	1028
4	KD	55	7	1045
5	KE	57	8	1068
6	KF	57	8	1069
7	KG	56	9	1134
8	KH	56	9	1147
9	KI	56	9	1174
10	KJ	56	9	1195
11	KK	58	10	1247
12	KL	59	11	1283
13	KM	59	11	1311
14	KN	59	11	1324
15	KO	59	11	1348
16	KP	59	11	1349
Tubagus Ismail 15				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	LA	48	5	956
2	LB	48	5	935
3	LC	48	5	924
4	LD	48	5	901
5	LE	48	5	932
6	LF	48	5	941
7	LG	48	5	952
8	LH	48	5	1005
9	LI	48	5	1034
10	LJ	48	5	1049
11	LK	48	5	1059
Tubagus Ismail 17				
No.	House Unit	Line Number	Depth Level	Metric Distance (m)
1	MA	54	6	1006
2	MB	54	6	1022
3	MC	54	6	1061
4	MD	49	7	1081
5	ME	49	7	1088
6	MF	49	7	1097
7	MG	49	7	1109
8	MH	49	7	1108

Based on the metric distance calculation resulted in Table 1, it was evident that only 20 units of rental housing that meet the standard distance of walk for transport, while the rest 88 units were below standard. In fact, there were 81,5% from the total housing units that did not meet the standard distance.

## 5. Result

According to the analysis, there were three important findings revealed as follows:

- Some areas with the lowest integration value had the deepest structure. The point is, this area had the most unideal structure for a rental housing region. An area with very low integration value and very deep structure is indicating that it is isolated and having low accessibility.

- The hierarchy range between the shallowest and the deepest areas were considerably high (14 levels). This interval was showing a significant depth levels throughout the Tubagus Ismail region's structure.
- According to the standard of walk for transport, most of the area in this region was considered as below standard. Therefore, the properness of Tubagus Ismail as a rental housing area surely needs to be reviewed.

## 6. Conclusion

With the mismatch between the rental housing area and the integrated public transportation system, there will be a raising on the private vehicle's possession inside the neighbourhood. This, may lead to another problem that could interfere the sustainable development of a city such as traffic congestion and exceeded carbon emission produced by the vehicles. Moreover, compared to the regular housing, rental housing region is having more contribution to this problem considering its higher population density per area. Hence, the properness requirement of rental housing region regarding its accessibility should be reviewed by the authority, so that the problems above could be minimized.

Despite the findings revealed, there were also several drawbacks in this research. In order to set a more accurate standard toward walk for distance accessibility in a residential scale, there should be an involvement from the inhabitant's perception toward the maximum distance for public transportation. Besides, another factor affected the sustainability assessment such as traffic, road physical condition, and walkability should be considered for a more holistic result. Therefore, further study to identify a more contextual perception about public transportation accessibility from the study case region is needed to be done.

## 7. References

- [1] M. A. M. Din, "The Aspect Of Walking Accessibility In The Development of GIS-Based Transit System Modelling In Kuala Lumpur," *International Journal of Digital Earth*, 2009.
- [2] P. Dursun and G. Saglamer, "Spatial Analysis of Different Home Environments in the City of Trabzon," in *4th International Space Syntax Symposium*, London, 2003.
- [3] S. Bafna, "The Geometrical Intuition of Genotypes," in *3rd International Space Syntax Symposium*, Atlanta, USA, 2001.
- [4] D. W. Wulandari and S. Mori, "Nature and Operation of Kost Private Rental Housing in Urban Settlement Development of Jakarta, indonesia," *Journal of Civil Engineering and Architecture*, pp. 1362-1369, 2015.
- [5] P. Widjaja, *Kampung - Kota Bandung*, Bandung: Graha Ilmu, 2013.
- [6] R. Daniels and C. Mulley, "Explaining walking distance to public transport: the dominance of public transport supply," *The Journal of Transport And Land Use*, vol. 6, pp. 5-20, 2013.
- [7] L. Aurbach, "TND Design Rating Standards," United States Environmental Protection Agency, Maryland, US, 2005.
- [8] HKL, "Public Transport Planning Guidelines in Helsinki, HKL publication series A," HKL Planning Unit, helsinki, 2008.
- [9] Public Transport Authority, "Design and Planning Guidelines for Public Transport Infrastructure: Bus Route Planning and Transit Streets," Public Transport Authority, Western Australia, 2003.