

Measuring accessibility of sustainable transportation using space syntax in Bojonggede area

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Abstract. Changes in the physical structure of regional space as a result of the increase of planned and unplanned settlements in the Bojonggede area have an impact on the road network pattern system. Changes in road network patterns will have an impact on the permeability of the area. Permeability measures the extent to which road network patterns provide an option in traveling. If the permeability increases the travel distance decreases and the route of travel choice increases, permeability like this can create an easy access system and physically integrated. This study aims to identify the relationship of physical characteristics of residential area and road network pattern to the level of space permeability in Bojonggede area. By conducting this research can be a reference for the arrangement of circulation, accessibility, and land use in the vicinity of Bojonggede. This research uses quantitative method and space syntax method to see global integration and local integration on the region which become the parameter of permeability level. The results showed that the level of permeability globally and locally high in Bojonggede physical area is the physical characteristics of the area that has a grid pattern of road network grid.

Keywords: sustainable transportation, space syntax method, accessibility, road network pattern

1. Introduction

Transportation and land use have a close relationship and are very dynamic and complex, because it involves several aspects of activities of various interests. The development and changes that occur in land use can have an impact on the development of transportation or otherwise. Changes that occur in the magnitude of movement and the selection of modes of movement is the result of a pattern of land use change above and any land use changes will certainly require an increase provided by the transportation system of the region concerned [1].

The basic concept of the interaction or relationship between land use and transportation is accessibility. Accessibility is a concept that incorporates geographical land use arrangements with the transport network system that connects them. Accessibility is a measure of convenience or ease of how land use locations interact with each other and the difficult or difficult location is achieved through the Black transport network system.



If adjacent land use and inter-use transport links have good conditions, then accessibility is high but if the land use is far apart and the transport links are poor then accessibility is low. The land itself can identify urban activities, where the type of activity is divided into 2 aspects: general (commercial and settlement) and special (which has more specific characteristics) and each type of activity requires the characteristics of a particular transportation system and in accordance with the generated movement generated [2]. In responsive environmental planning, the road network as a land use liaison is the main thing to note [3].

The close relationship between the road network and the surrounding land-use affects the mobility and accessibility of movement within the network that can improve the quality of a region. A good road network can increase permeability in the region, and ultimately can improve the quality of a region. Areas with high permeability will improve the local economy tangibly, allowing people to walk and cycle, improve health, and increase social capital.

Permeability is a desirable characteristic of a place in terms of ease of movement from one location to another. These places must be integrated or connected physically with the surrounding area [1]. Permeability is used to measure the extent to which the configuration of space provides an option in traveling, where the configuration itself is a set of relationships where there are interdependent objects in structure [4].

To understand of the matter, the researcher uses space syntax method to see the connection of a space network. The location of the research is selected in Bojonggede area which is the second densest settlement area in the Bogor regency area which experienced many changes in the configuration of the spatial area due to the increase of planned and unplanned settlements as well as impact on the system of road network and permeability of the area. The emergence of a hierarchical layout due to the cul-de-sac road pattern, a dead end and a few choices of road routes in the Bojonggede area makes the road network less permeable, whereas the road network should maximize connectivity between destinations to promote the level of permeability to road users.

2. Literature review

2.1. Physical Characteristics

The pattern of settlements in an area consist of buildings and spaces that make up the physical configuration. Physical spatial configuration of the area can be open space (void), can be a road, plaza, poche, park, etc. while the mass configuration of buildings in the form of land occupancy blocks, and edge [5]. The relationship between landuse forms a regional pattern comprising the following mass and spatial relationships [6]:

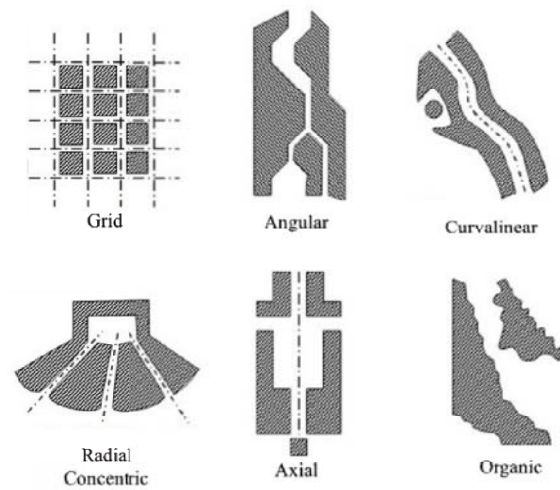


Figure 1. Pattern configuration of building mass (solid) and open space (void)

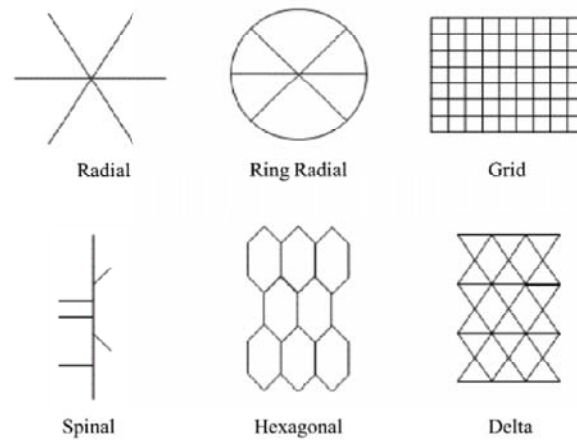
Urban texture is the degree of order and mass density and space in urban areas consist of three typologies: (1) homogeneous texture; configurations formed by mass and space relatively equal to both size, shape and density, (2) heterogeneous texture; configurations formed by mass and space of different sizes, shapes and densities, (3) sprawl texture is a configuration formed by mass and space whose size, shape and density are so heterogeneous that it is difficult to define them [6].



Figure 2. Urban Texture

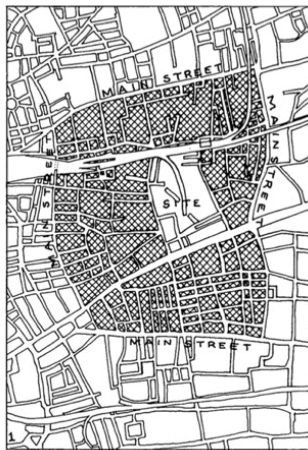
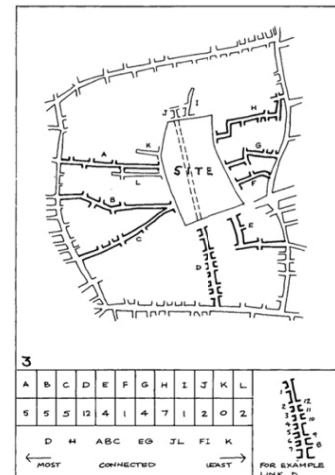
2.2. Characteristics of the Road Network

The network of circulation systems that form road network patterns becomes an important component in urban design as it affects aspects of space quality in terms of permeability and accessibility[4]. Road network pattern is a road network that has several patterns such as grid (grid), radial, radial ring, spinal, hexagonal, and delta [7].

**Figure 3.** Road network pattern

2.3. Level of Permeability

Permeability is a desirable characteristic of a place in terms of ease of movement from one location to another. These places must be integrated or connected physically with the surrounding area. To measure the level of permeability of an area, there are two permeability analysis scale that need to be done, among others: (1) analyzing the link that connects the area to all cities; (2) analyze the link that connect the area to the surrounding environment. The first step that needs to be done is to find the main road that covers the area (perimeter block) (See Figure 4). The second step is to find the most directly connected (path) link with the main road (See Figure 5). This can be assessed by comparing the number of view point changes along the link from the main road to the area. The next step is to calculate how many transitions (turns) are located on a link (path). The more transitions (turns), the higher the link is connected to the local area (See Figure 6) [3].

**Figure 4.** Block perimeter area**Figure 5.** Counting the switch (turn)**Figure 6.** Calculating the road segment

2.4. Space syntax.

Space syntax uses a distance concept called (depth) measured in steps called topological distance [8]. The level of permeability can also be measured through the space syntax method through the measurement of integrity and connectivity [9]. Space syntax sees permeability from the point of view (visibility) as outlined in a method called visual graph analysis (VGA). VGA is a method in space syntax for analysing, comparing visual fields viewed from various layout spaces as well as calculating and informing the user's location visually. Each point has a value of "accessibility space". This value reflects the complexity of the route from one point to another in a system. This visual complexity affects motion in two ways, ie an integrated location will be more accessible in general, so it can be achieved by a simple route from another location; "Separate" locations within the system will be difficult to reach from other locations. As a result of that integrated location will be more potential to be selected as part of the route to attract more movement.

3. Methodology

The data consisted of primary and secondary data, where the primary data consisted of the characteristics of the area and the pattern of the road network, obtained from the interpretation of land use maps and aerial photography/satellite imagery, and field observations, for the level of permeability of the area obtained by the method space syntax. Secondary data is obtained from books, online internet, research results or literature review, administrative maps, and applicable laws and regulations. Stages of research conducted include:

- Identify the physical characteristics of the area through a figure-ground analysis to see the mass and space patterns and the texture of the area in a small macro.
- Identify the characteristics of the road network by looking at the pattern of the road network on the region through the map.
- Measure the level of permeability by using space syntax with axial map method using the software tool of DepthMap ver 10. In the Depthmap application space is represented by the color gradation red to blue. The red color has the highest permeability value, while the lowest value is blue.

The sampling technique used is purposive sampling technique. In this study the sample is determined based on settlement areas that have a variety of spatial structure patterns, both from the pattern of mass and space and the pattern of the road network. The boundaries used in each region are the boundaries of the Rukun Warga, the village settlements, and the boundaries of the planned housing areas. The number of samples specified is 30 samples of residential area

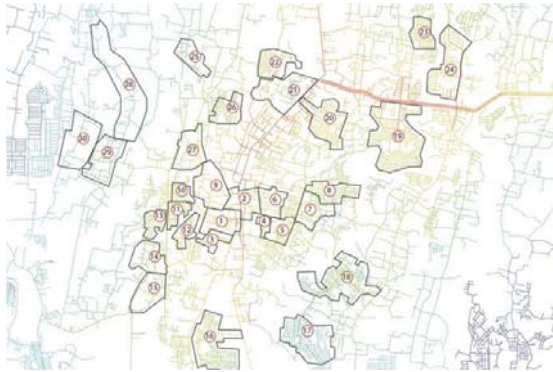
4. Results and Discussion

4.1. Physical Area, Road Network Pattern, and Level of Permeability

The analysis was conducted on 30 samples located in Bojonggede area of Bogor Regency.

1. Kedung Waringin Bojonggede (RW 01, 02, 06)	13. Perumahan Puspa Raya
2. Perumahan Trans Bojonggede	14. Perumahan Bambu Kuning
3. Perumahan Gaperi Genteng Biru	15. RW 07 Kampung Sawah
4. Perumahan Gaperi I, II, III	16. Perumahan Villa Asia
5. Rukun Warga 15 Bojonggede	17. Perumahan Perdagangan
6. Perumahan Bojong Depok Baru I RW 16	18. Perumahan Bumi Cibinong Endah
7. Rukun Warga 13 Bojonggede	19. Kampung Susukan
8. Perumahan Bukit Waringin (RW 10& 11)	20. Perumahan Griya Yasa Lestari
9. Perumahan Bojong Gede Asri	21. Kampung Sawah Poncol
10. Perumahan Bukit Waringin RW ?	22. Kampung Nanggela
11. Sudimampir (RW 02 & 03)	23. Kampung Sukmajaya
12. Perumahan Puri Artha Sentosa	24. Kampung Tegal Petir

Figure 7. List of sample area

**Figure 8.**Global Integrity**Figure 9.**Local Integrity**Table 1.** Result of analysis of physical characteristics of area, road network, and level of permeability.

AREA	PHYSICAL CHARACTERISTIC OF AREA				ROAD NETWORK Road network pattern	LEVEL OF PERMEABILITY	
	Building Function	Pattern of Mass and Spacw	Texture in a small macro	Mass density		Global Integrity	Local Integrity
1	Live, Work, Facility	Organic	Sprawl	High	Spinal	0,305	2,102
2	Live, Work	Organic	Sprawl	High	Spinal	0,310	1,890
3	Live	Angular	Homogeneous	High	Grid	0,263	1,757
4	Live	Grid	Homogeneous	High	Grid	0,260	1,800
5	Live, Work, Facility	Angular	Heterogeneous	High	Grid	0,257	2,140
6	Live, Facility	Organic	Heterogeneous	High	Spinal	0,264	1,860
7	Live, Work	Organic	Sprawl	High	Spinal	0,233	1,534
8	Live, Work, Facility	Grid	Homogeneous	High	Grid	0,239	2,512
9	Live, Work, Facility	Organic	Sprawl	Middle	Spinal	0,277	1,875
10	Live, Work	Grid	Homogeneous	High	Grid	0,249	3,111
11	Live, Work	Grid	Homogeneous	High	Grid	0,248	2,720
12	Live, Facility	Spline	Homogeneous	High	Spinal	0,263	2,970
13	Live, Work, Facility	Grid	Homogeneous	High	Grid	0,249	2,533
14	Live, Work	Organic	Sprawl	Low	Spinal	0,228	1,555
15	Live, Work, Facility	Organic	Sprawl	Middle	Spinal	0,235	1,613
16	Live, Work	Angular	Homogeneous	High	Grid	0,260	2,579
17	Live, Facility	Grid	Heterogeneous	High	Grid	0,183	2,601
18	Live, Work	Grid	Homogeneous	High	Grid	0,200	2,574
19	Live, Work, Facility	Angular	Heterogeneous	High	Grid	0,292	2,556

20	Live, Work, Facility	Angular	Heterogeneous	High	Grid	0,314	2,690
21	Live	Organic	Sprawl	Low	Spinal	0,255	1,700
22	Live	Grid	Homogeneous	High	Grid	0,249	2,611
23	Live, Facility	Grid	Homogeneous	High	Grid	0,251	2,703
24	Live, Work, Facility	Grid	Heterogeneous	High	Grid	0,288	2,253
25	Live	Spline	Sprawl	Middle	Spinal	0,213	1,813
26	Live, Work, Facility	Spline	Homogeneous	High	Spinal	0,247	2,071
27	Live	Spline	Sprawl	Low	Spinal	0,274	1,570
28	Live	Spline	Sprawl	Low	Spinal	0,183	1,900
29	Live, Facility	Spline	Sprawl	Low	Spinal	0,200	1,673
30	Live	Spline	Sprawl	Low	Spinal	0,180	2,085

4.2. Relationship of the physical characteristics of the area to the Level of Permeability

The physical characteristics of the area consist of mass and space patterns, small macro textures, and road network patterns. The degree level of permeability consists of global and local integration. The analysis used variance analysis and processed using SPSS application to see the relation between variables.

a. The relationship between mass and space patterns with global and local integration

Based on the analysis results, the pattern of mass and angular space has a higher level of global integration compared to other typologies. and the lowest level of global integration is spline-based. From the results of previous analysis, it can be seen that this mass pattern has a pattern of grid pattern road. (See Figure 9). The mass and space patterns of local integration that have high level of permeability are mass and angular typological patterns, while those with low level of permeability are organic. (See Figure 10).

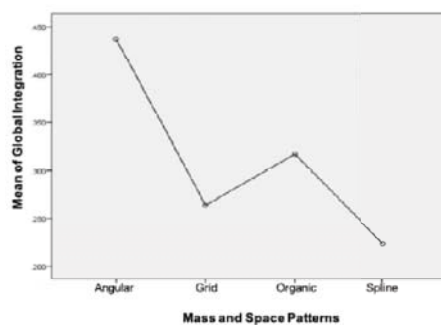


Figure 10. Relationship between mass and space patterns with global integration

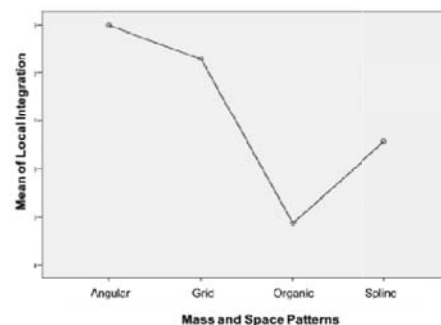


Figure 11. Relationship between mass and space patterns with local integration

b. The relationship between textures in a small macro with global and local integration

From the analyst's results it is seen that a small, heterogeneous macro-macro texture has a high degree of global integration. In this typology the road network pattern is mostly grid. (See Figure 12). Small, homogeneous macro textures have high local integration compared to others. The most have the lowest local integration is a small macro texture that has an obscure texture. (See Figure 13).



Figure 12. The relationship between small macro textures and global integration

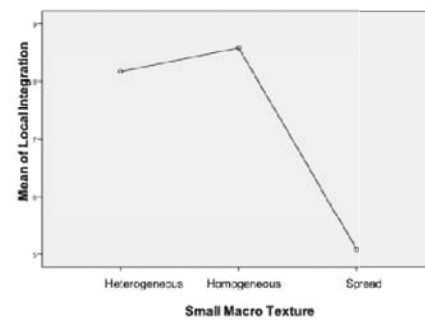


Figure 13. Relationship between small macro texture with local integration

c. The relationship between road network patterns with global and local integration

Road network patterns that have grid typology have higher global and local integration than spinal. This is in accordance with several theories that have been proposed, that the grid pattern has the highest level of permeability than to other road network patterns. (See Figure 14 and 15).

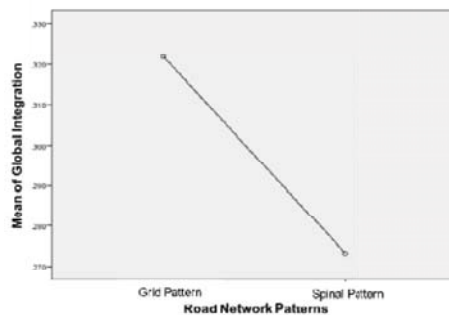


Figure 14. The relationship between the pattern of the road network with global integration

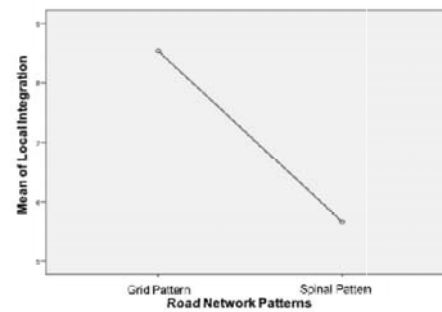


Figure 15. The relationship between the pattern of the road network with local integration

5. Conclusion

Based on the results of the analysis and discussion can be concluded that to achieve the level of permeability for globally and locally integration higher than the road network pattern with grid patterns. The grid pattern has a good level of visibility where it can easily see by preferred routes. Grid patterns tend to have regular patterns and easy to reach, so these patterns should be located in the centred of the area, making them more accessible from different places.

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