Characteristics of Urban Tissue Pattern of Inner City and Coastal City in Indonesia (Case Study: Depok District, Yogyakarta and Genuk District, Semarang)

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Abstract. In the realm of urban planning and design practice, understanding urban morphology can be the basis for the physical development of the built environment that is adaptive and transformative to the uncertain and rapid changes in urban areas. This study aims to identify the physical form that is expected to represent the character of the development of Indonesia’s urban areas in Yogyakarta as the 'Inner City' and Semarang as a 'Coastal City'. The research used an NDBI map within two different timescales to identify the figure and ground of both case studies to generalize the urban tissue pattern. The initial results show that the two districts have a similar tendency to develop heterogeneously and dispersed with the predominant configuration of figures arranged through field blocks and open system urban fabric. However, the two districts also have differences that represent the physical characteristics of the inner city in the form of a low-density continuous development pattern and a coastal city in the form of a linear development pattern. The characters show the process of shifting from closed urban fabric to open-fragmented peri-urban fabric.

Keywords: urban morphology, urban dualism, figure-ground analysis, transformation

1. Introduction
In the realm of urban development practice, understanding urban morphology can be the basis for the physical development that is adaptive and transformative to the uncertain and rapid changes in urban areas [1]. Through a morphological perspective, the study of urban forms not only discusses the character of the physical form but also the history of its development. Good integration between morphological studies and urban studies can encourage better urban place-making [2].

One of the spatial studies that aim to identify urban morphology is through figure-ground or urban tissue analysis [2]. Urban tissue analysis is one of the dimensions in the study of urban morphology to investigate the structure and interrelationships in the physical elements of urban space [3]. The concept offers an effective framework for generating the character of a city [4].

Most analyzes of urban morphology are concerned more about historical rather than modern urban tissue [5]. In fact, with the current urbanization phenomenon, the urban landscape has changed radically. The complexity and uncertainty of urban dynamics cause urban planning and design to have difficulty predicting the trend of future urban fabric development [6]. Therefore, research on the physical forms...
of modern urban areas is very important, not only to explore the form of cities but also to develop adequate methods and tools analysis for future planning and design practice.

Indonesia has undergone a rapid urbanization process which produces different characters in each region. Referring to the history and character of its development, cities in Indonesia can be divided into two typologies, namely “Inner City” as cities developed in the inland area and “Coastal City” as cities developed in the coastal area [7]. The dualism of this pattern of development has encouraged the development of modern urban areas in Indonesia today, especially on the island of Java. Past cities on the island of Java, metaphysically and aesthetically, developed through acculturation of high cultural diversity. However, the development of today's cities has obscured the value of this space. The shift in social and spatial structure has changed the perspective of interpreting space. This is reflected in the development of the physical structure and function of urban areas.

This study aims to identify the characters of urban tissue patterns in Yogyakarta as the 'Inner City' and Semarang as the 'Coastal City'. Each of them will take a case study in Depok District and Genuk District. The two districts were chosen as a representation of the physical development of urban space as a result of the urbanization process. If the urban morphology studies that have been carried out previously focused on discussing urban forms in the old city center as urban core, this research will highlight urban forms in urban fringe areas. The two districts are case studies for the development of urban areas in the modern era in Yogyakarta City and Semarang City.

2. Urban Tissue Approach in Urban Morphology Studies

Urban morphology is the study of the physical structure of the city and its change processes with a broad spectrum, from the building to the metropolitan scale [2]. Urban morphology can be explained through three principles, namely form, resolution, and time [8]. To define the urban form fundamental physical elements include buildings and associated open spaces, plots or plots, and roads [8]. One of the concepts that can identify these three elements to describe urban form is urban tissue. Urban tissue is a synthesis of all seven hierarchical components consisting of materials, structures, spaces, buildings, plots, serial plots, and roads [4]. Simplification of tissue in the form of a plan unit consisting of a unique combination of buildings, plots, and roads [4].

In the study of urban morphology, an urban form can be interpreted as an urban fabric [5]. In this case, a figure-ground image could represent the geometry of the urban fabric by identifying building mass and open space and the textural relationship between the two as seen in Figure 1 [9]. In general, the elements in the figure-ground analysis are grouped into two, namely solid and void. Through both, the urban form will be studied from the aspect of the textural pattern of the area, the nature of solid and void elements, and the pattern of urban units [9]:

1. The urban textural pattern is the identification of figure-ground macro to produce a pattern or arrangement of areas that are homogeneous, heterogeneous, and/or disperse.
2. Solid and void as urban elements each form the nature of the basic elements. The three basic elements that are solid are single blocks, edge-defining blocks, and field blocks. While the four basic voids are a linear closed system, central, closed system, central open system, and linear open system.
3. An urban unit is several masses and spaces that have an identity as one group. Diagrammatically, urban units can form angular, axial, grid, curvilinear, radial, concentric, and organic patterns.
3. Methods
In this study, the identification of urban tissue will be carried out using a spatial analysis approach. The research was conducted by analyzing images at two different timescales to produce the characteristics of the development of the built-up area within a period of 10 years. The analysis was using Normalized Difference Built-up Index (NDBI) which has been proposed as a technique that can map urban land cover automatically from the imaging satellite [10]. Although NDBI has limitations, the technique is already commonly used for built-up areas extraction.

NDBI (Normalized Difference Built-up Index) or built-up land index is an algorithm method in GIS that is used to compare the density levels of built-up area. The technique works with multispectral sensors with Short-Wave Infrared (SWIR) and Near-Infrared (NIR) bands. NDBI focuses on urban areas or built-up areas where there is usually a higher value reflecting effect in SWIR areas compared to NIR areas. NDBI values range from -1 to +1 where the higher the value is considered the built-up area [10]. Calculation of NDBI is displayed in equation 1:

$$\text{NDBI} = \frac{\text{SWIR} - \text{NIR}}{\text{SWIR} + \text{NIR}}$$ (1)

This research was carried out with the following steps: (1) retrieval of SWIR and NIR band layers; (2) generation of NDBI layer; (3) convert raster to vector data; (4) interpretation of NDBI Map to generate urban tissue characteristic by using figure-ground analysis, with details as shown in Figure 2.

![Figure 2. Workflow of NDBI Analysis](image)

Remotely sensed data images were acquired from the United States Geological Survey (USGS). The acquired information of images is as shown in Table 1.

| Location | Satelit       | Date    | Sensor              | Spatial Resolution | Projection                     | Data band |
|----------|---------------|---------|---------------------|--------------------|--------------------------------|-----------|
| Depok    | Landsat 4-5   | 19.10.2009 | Thematic mapper TM  | 30m                | WGS_1984_UTM_Zone_49S          | Band 1,2,3,4,5,7 |
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| Location   | Satellite | Date       | Sensor                                      | Spatial Resolution | Projection                      | Data band        |
|------------|-----------|------------|---------------------------------------------|--------------------|---------------------------------|------------------|
| Genuk      | Landsat 4-5 | 11.02.2011 | Thematic mapper TM                           | 30m                | WGS_1984_UTM_Zone_49S          | Band 1,2,3,4,5,7 |
| Genuk      | Landsat 8  | 24.04.2020 | Operational Land manager and thermal infra-red sensor OLI/TIRS | 30m | WGS_1984_UTM_Zone_49S | Band 1,2,3,4,5,7 |

4. Results and Discussion

In this study, urban tissue analysis uses a macro-scale figure-ground interpretation approach. The limitation of the results of the NDBI analysis which is not yet able to distinguish in detail between the built-up land and the surrounding vacant land [11] results in a more general figure-ground picture. This limitation is also coupled with atmospheric disturbances in remotely sensed data acquired that affect the reflectance of the image even though it has been corrected. However, the results of this analysis can be a start in investigating the shape of the city and the pattern of its development on a macro scale. On a macro scale, figure-ground analysis pays attention to the overall characteristics of urban texture, not per part of the area [9].

Based on the NDBI layer shown in Figures 3 and 4, the results show built-up area changes from within 10 years. Visually, significant changes occurred in Genuk District from 2011 to 2020 with the spread of the built-up area to the east-south direction. Meanwhile, from 2009 to 2020 in Depok District, more changes occurred with the infill development in the built-up area, while the spread only occurred in the east direction. In general, the figure-ground texture pattern in the two districts is of low quality with an irregular character that can be seen on the visual NDBI map. Through a more detailed interpretation of the results of the NDBI map, the character of urban tissue analyzed from a figure-ground perspective [9] can be seen in Table 2.

Figure 3. NDBI Map for Built-up Areas Development from 2009-2020 in Depok District
Figure 4. NDBI Map for Built-up Areas Development from 2011-2020 in Genuk District

Table 2. Urban Tissue Characters Through Figure/Ground Analysis

| Location     | Year Build-up Area Map | Characteristics |
|--------------|------------------------|------------------|
| **Depok District** | 2010 | ▪ The composition of the area is heterogeneous  
▪ Figure configuration with masses or blocks seen figuratively  
▪ Ground configuration with open space seen figuratively  
▪ The dominant urban elements are field block (solid) and linear open system (void)  
▪ The urban texture pattern is organic |
|              | 2020 | ▪ The composition of the area is heterogeneous and disperse  
▪ Figure configuration with masses or blocks seen figuratively  
▪ Ground configuration with open space seen figuratively  
▪ The dominant urban elements are field block (solid) and central open system (void)  
▪ The urban texture pattern is organic |
| **Genuk District** | 2010 | ▪ The composition of the area is heterogeneous and disperse  
▪ Figure configuration with masses or blocks seen figuratively  
▪ The dominant urban elements are field block (solid), linear closed system (void), and central open system (void)  
▪ The urban texture pattern is partly curvilinear and partly organic |
On a macro level, the urban texture patterns in the two districts are heterogeneous and disperse. The heterogeneous arrangement of the area can be seen from the pattern of solid and void shapes which tend to be diverse and do not show the same unified form. The dispersion pattern in Depok District looks on the 2009 and 2020 maps with solids arranged irregularly in the eastern part of the area. Meanwhile, the dispersion pattern in Genuk District is visible in 2020, where solid growth is scattered in an east-south direction. Most parts of the district's area are dominated by figure configurations with solid shapes that better define urban form. However, some parts of the area also have a ground configuration such as open spaces in building areas with public functions, e.g. universities or airports in Depok District. Based on the physical appearance on the map, solid elements are dominated by field blocks while void elements consist of a linear closed system which is quite visible on the Kaligawe Raya road in Genuk District; a central open system spread over several parts of the area in the form of fields, agricultural land, and other vacant lands; and linear open system is found in the area around the river flow.

Urban fabrics that are produced from the textural relationship between the mass of buildings and open spaces develop through patterns of physical spread of the city. As shown in Figure 5, Depok District has a spread pattern [12]: (1) Low-Density Continuous Development and (2) LeapFrog Development. Meanwhile, Genuk District has the following spread patterns: (1) Linear Development and (2) LeapFrog Development. The two districts experienced leapfrog development, resulting in an irregular pattern of built-up areas, which tended to be sporadic, and visually unaesthetic. In addition, Depok District is also experiencing a process of low-density continuous development. This pattern is the spread of the built-up area slowly evenly to all parts of the existing city features [12]. Depok district has experienced this spread, especially in the western part of the area which has indeed developed rapidly with the agglomeration of the higher education area. In this part of the area, the increase in the built-up area is mostly done through infill development on the bare land around the area that has been built. With this spread pattern, Depok District has the potential to develop compactly, especially with the increase in building density and height. Meanwhile, in Genuk District, the role of transportation routes and their geographical location in the coastal area is quite large in influencing how the built-up area develops linearly. However, in the last 10 years, the development of built-up areas in Genuk District tends to be scattered due to the increasing threat of coastal flooding. Apart from the high danger of coastal flooding, Genuk District has the highest residential land area growth rate in Semarang City [13]. It seems that this pattern developed as a form of adaptation to the phenomena.
5. Conclusion

Based on the results of the NDBI analysis and the associated limitations, an early generalization of the urban form and development of the Depok and Genuk districts can be made. The NDBI map shows the mass (solid) and open space (void) of the building used in the figure-ground analysis to investigate the characteristics of the urban tissue. From the initial results, it can be concluded that the two districts are heterogeneous and dispersed. These characters are the representation of the sprawl development of suburban areas. However, it shows a different development pattern for ±10 years. The Depok District, which is part of the inland city, shows a more compact appearance as a result of low-density continuous development from the center of Yogyakarta city. Whereas as a coastal city, the Genuk District shows a more scattered appearance affected by the physical geography of the coastal area, the transportation infrastructure under development within the district, and the threat of coastal floods.

Due to the limitations of the NDBI analysis results, it is not possible to optimally use solid void details to identify the nature of urban elements and patterns. However, the first generalization of geometry at the macro level can provide preliminary conclusions about the structural relationship between building mass and open spaces. In general, the solid image shows the strength of the figure configuration compared to the ground configuration. In addition, solid elements are field blocks and void elements are open systems. Urban fabrics represent the frequent changes in closed systems of the city center towards open systems that develop in the suburbs. This is the so-called shift from closed urban fabric to open-fragmented peri-urban fabric [5].

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