Building age profile and figure-ground image: defining the urban development pattern of Balikpapan City

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Abstract. As one of Indonesian city that emerged from the industrial sector, Balikpapan grew and was inhabited by transmigrants from various cultures. The development and growth patterns of the Balikpapan urban area was influenced by the culture of the residents, due to the absence of empire influence or colonialism. This research was conducted to identify the oldest area as a starting point of the urban development patterns of Balikpapan. The building-age profile method was used to identify the oldest building groups or blocks, which belong to the city's heritage zone. In this analysis, a series of figure-ground images in several periods were collected to indicate the building age. Through the process of overlaying solid-void maps, the pattern of space-built interaction was generated as the patterns of urban development. Results shown that urban development, which was determined through overlay technique, was organic pattern, which was formed by several connected irregular shapes. The conservation of the urban pattern indicates the effort to achieve urban identity, as one of the sustainable urban form indicator.

1. Introduction
The development of Balikpapan began with the discovery of oil in the coastal region around 1895, which was later developed by a large oil company, namely De Bataafsche Petroleum Maatschappij NV. The growth of a large trading joint venture in Balikpapan gave rise to some subsidiaries which contributing to population growth, especially the company workers. Employment opportunities in the oil industry sector in 1987 led to a big wave of migration to Balikpapan. In the next years, migrants from diverse tribes inhabited Balikpapan. At the beginning, there were three large group of settlements by the custom, Banjar, Bugis and Javanese [1]. Balikpapan as a coastal city also shows several forms of fisherman settlements that stretch from the west coast to the east. Big port in Balikpapan plays an important role as an entrance for industry, goods and migrants to the surrounding areas [2]. The development of cities which inhabited by migrants may be different from cities inhabited by indigenous people. People who formed the earth surface and spaces according to their needs for life form cities. Space that occupied by humans, the boundaries are buildings. Humans interact and utilize resources to form relationships between spaces, and so, the relationships between human nature and human-human interaction cause the formation of roads as intermediaries [3]. This interaction might be not easy to be interpreted. For instance, each home environment has its characteristics and specifications based on cultural and social elements of the owner. Users can have perceptions about ways and desires to provide space, and what it is used for. In addition, user adaptation and needs affect
the formation of space that might be different with others, even by people with same culture [4]. It can also be understood by a study of culture and environmental public participation. Such cultural aspects like religion, democratic culture and gender are clearly determining the environmental participation. Those factors indicate certain characteristics such as fatalist, individualist and hierarchical, that will define people’s participation [5]. The theory of relationship between society and architectural and urban forms is best known for treating space directly as a differentiator of social reality and the most influenced by architecture is “territorial theory”. This theory exists in various types, but the main principles are the same. First, the organization of space by humans is said to be biologically an individual impulse to claim and defend the sign of "territory", from other individuals who are not included in it. Second, this principle can be extended to all levels of human groups (all humans will claim and defend an area in the same way that other individuals will do). A city consists of two different spatial components, namely the road system, which is a place for daily transactions, and the space of public buildings. Collection of humans is a spatial phenomenon, that occupy space on the surface of the earth forming regions and between these regions there is a movement of resources, both the public and information disseminated [6].

The morphological research of the city is carried out not only to identify the city morphology in the present, but also to track the development of the city pattern since the time of its formation. Looking at pattern through series of maps of urban space in several growth periods, this research is focus on the formation of urban settlement layers.

2. Theory

2.1. Urban Morphology

Urban development is a process of changing urban conditions from one state to another in a different time [7]. This change happened physically as the impact of urban population characteristics. One study found that the vast alteration of an urban area was mostly influence by infrastructure development. It affects the construction direction that forms a general urban structure in a whole [8]. In particular, urban growth depends on the geographic aspect that will decide the block’s orientation, order, even the building scale. Other aspect that found in a rather dense country or city, land prices become one consideration and motive for particular urban form.

Urban morphology is used to provide a descriptive picture of a built environment in cities, suburbs or rural areas. Widely used in vast variety of fields, it helps researchers to understand the specific and distinctive characteristics of an area. Some uses of urban morphology include tools to provide descriptions and general explanations about the development of the built environment, to investigate environmental quality, as a strategic planning and policy-making, provide an overview as a basis for designing guidelines or codes, and as an appraisal tool for characteristics assessment and heritage management [9]. To specify the use of urban morphology as redevelopment guidelines, it needs combination and integration of the map of characteristics and property holding. Morphological analysis, data collection and area mapping of urban area can influence the future design and planning decision-making [10]. As the majority of people live in the city today, the recognition of urban characteristic is needed not only by its physical appearance, but also by its cultural impact to the environment. Multidisciplinary viewpoints are necessary to obtain a comprehensive understanding of urban circumstances. Comparing several data from various methods, for example evaluation, structures and models assessment and comparative studies are important for a strong research observation [11]. Vast various of viewpoints that can illustrate a wider description of urban morphology including activities, authority, social and economic aspects, and the most intangible one is impression [9].

Based on urban morphological study in Malang, Indonesia, urban form that is shows in its visual two-dimensional pattern can be define functionally and visually. Buildings, lots, and street networks are urban elements that depict the space linkage. It can also show the sense of place by the space configuration of solid and void. Comparing to the three-dimensional object, the building function also
give an important data about how the place was formed [12]. In further application, research by Ibrahim [18] shown that urban form investigation were fundamental in the creation of sustainable resident, specifically to support the sustainable urban form. To be precise, there will be a significant effect of urban pattern in sustainable urban form in term of space and street network connectivity. It is related not only within the neighbourhood, but also in the interconnection between districts.

2.2. Building-age profile
To identify the starting point of urban development, the building-age profile map used to obtain an overview of areas that been built in a particular era. A series of maps were used to determine the exact location of buildings from a certain period. The map not only shows the distribution of buildings age, but also the urban development pattern of a city [13]. Structuring the building-age maps, solid-void diagrams are needed to illustrate the relationship between space and built-up area in the. Figure-ground technique is used not only as a tool to define existing solid and void interactions, but also to find out the possibility of developing urban patterns in the future. The discovery of the oldest urban network pattern can guide architects or urban planners in recognizing an area or city in a more sustainable planning process. In this case, the city's heritage area can be identified as a unique artefact that will be maintained or redeveloped through the role of infill building and other forms of redevelopment [14].

2.3. Figure-ground
Such approach in the process of observing cities through the form of space and built-up areas is figure-ground. The focus on patterns and relationships between solid/figures (buildings) and voids / ground (open spaces in between) aims to identify the texture and spatial patterns of urban fabric. In the process of observing or “reading” the area, the consideration of figure-ground can be used as a basis for form reference and identify its spatial character. Information about the consistency and changes in patterns, functions and systems that shape urban patterns can be found through solid and void maps. In addition, subtraction or change in geometry can be done through a two-dimensional image of the overall city structure. The form of urban solid can be determine by its connection to other solid, such as orthogonal which is a modification of grid, free form (organic) and concentric that can be linear, central or radial [15]. Along with those statements, figure-ground plan is also stated as the only graphical method to reflect a city’s morphology by pushes aside not only physical factors such as aesthetics quality, visual culture, skyline and ecosystem, but also non-physical factors such as ownerships, human agency, status, gender and mobility. The use of it was also developing from two-dimensional map presentation to a multidimensional image supporting by information system. Graphic software help researcher explore both block and building configuration [16].

3. Methodology
This research used the historico-geographical approach in urban morphology through different period of development to demonstrate the city structure, urban pattern and the characteristics of urban settlements. Graphical steps scrutiny the growth of buildings pattern through time and draw the development phase in building-age map. Not only does this approach clarify the natural composition of precinct in a certain period, but also illustrate the morphological process of a city [9].

In the process of determining the building age, the step including stacking figure-ground maps from several periods produces dark to light areas, which indicates the existence of the building. The map is correlated with the physical characteristics and building styles in the area to infer the buildings age in the area. Mapping techniques are used to determine the pattern of urban areas in Balikpapan. This research used mapping technique specifically by compile several maps to reveal the starting point of development, as well as the oldest quarter of Balikpapan. Overlay mapping is a graphic technique that uses several figure-ground maps to obtain information related to the area with the oldest age. In addition, the relationship between old and new areas is also seen from the solid void formation [13].
4. Discussion
Balikpapan is one of big city in East Kalimantan Province that has abundant of natural resources, especially in mining, forestry and marine resources. Located in the southeast region of Borneo Island, the city has a essential role as the gateway of the norther area. It also located near the propose area of Indonesia’s new Capital City, Penajam Paser Utara District, which actualy was part of Balikpapan city area until 1959. Despite the long coastal line of the city, the center and the north part is mountainous that cover almost 85% of the city area.

![Figure 1. Balikpapan Municipal Area (2012)](image1)

Based on data obtained on Balikpapan City official website, the built-up area began to grow since 1939, as shown in Figure 1. Most built-up areas were established around and along the coast, specifically near the area where oil wells have been found before. However, there has not been found any geographical data obtained about residents who inhabited Balikpapan before that year. In 1987, the area of the city began to grow rapidly after the local government had officially built a business area in the southern part of the city.

![Figure 2. Balikpapan Map in 1939](image2)
Figure 2 illustrates the early condition of Balikpapan since an oil company existed in the southwest part of the city. It can be seen that most of the area on the west coast of Balikpapan was the area of oil companies, such as ports on the west coastline, oil tanks, buildings and streets. Based on the history, the company not only built their territory, but also the city infrastructure. In the centre part to the north, the oil tank zones were placed in clusters that were not fully built, but connected by a green open space. The built-up area of office buildings and employee houses was built more densely with a grid pattern to the south of the tank zone.

This research identifies 4 periods of the city development, 1987, 1996, 2016 and 2019, which were selected based on the most dominant distribution of built-up area. Each period was depicted in a figure-ground map within the city scope according to satellite imagery data. In the process of investigation, instead of using only solid and void map, some data such as background history and physical characteristics were used to scrutiny the process of urban area expansion.

![Figure 3](image1.png) **Figure 3.** Figure-ground Map Over Times  
![Figure 4](image2.png) **Figure 4.** Area Percentage Over Times

Figure 3 shows a figure-ground map with different colour intensities in the solid or built-up area. It can be seen that the most populous area of the city is in the southwest part around the oil company area. Based on the direction of its growth, looking at the solid distribution, the built area is seen growing along the main street. The darkest colour is seen spread around the oil company area, then developing to spread making the next layer of residential areas. However, the growth does not only occur in the area around the oldest part of the city, group of buildings is lined up along the main road on the east coast. As shown in Figure 4, construction in the city increased dramatically from 1987 to 1996, while the development around 2010s was slowing down. The black shaded area is the oldest buildings that have existed since 1987, where it was not only formed a unite area, but also create several lines that spread and are interconnected as the initial construction of the city.

The major development in 1996 was in the inner part of the city structure that had existed since 1987. Residential areas grew in the central part of the city and spread out not far from the old area. While the growth of the built-up area on the city’s main street in the south is business and commercial district. The east coast section is also developing to become denser with buildings, especially settlements and industries, based on the current conditions. The new buildings are shown with a lighter colour that was built after 2016. There was no massive manufacture, especially along the main road, but the built-up areas grow gradually. Recent development tendency is groups of buildings built on the inner part.
Comparing with Figure 1, the southwest area of Balikpapan has been expanded significantly since 1987, becoming a dense block of solid. Back in 1939, there were only well-organized patterns of corporate building established, but in 1987, as shown by the darkest color of solid, there were an organic form of buildings surrounded the company zone. As the main street connected the southern and northern part of the city, it influenced the growth of this settlement. Still in Figure 5, the dark grey part is the next development that mostly residential.

Figure 6 expose the progress of the most dense part of the city that grew rapidly from 1987 to 2016. The development in 1996 was quite intense, especially for small house that form a compact neighborhood. While the solid configurations around the oldest area tend to be organic, the buildings with the same age that located in the street extension are regularly arranged. The form of formal housing with grid formation exists from this point, particularly in deeper area of the city structure.
One part of the city that is also experiencing a rapid growth is the area around the east coast. The built-up area that has existed since 1987 occupied the area on the edge of the main road. Based on the current conditions, the area of military base, industry and fishing settlements can be seen along the road. During its development, buildings construction in 1996 settled the street branch, both to the north and south. A river estuary also becomes an organic growth point for the region, which is dominated by farmers and fishermen. The following growth indicates the existence of a regular and organized solid formation.

According to the building-age map (Figure 4) of Balikpapan, the growth of urban areas was rapid at the beginning of the city’s existence in 1987-1996. The highest expansion to the built-up area occurred in 1996, before lessen in 2016 and 2019. The central markets mainly influenced residential and public facilities growth in 1996. This was stated in the book of Balikpapan Tempo Doeloe, that along with the industrial sector, Pandasari Market and Klandasan commercial area became a trigger for the city development [2].
The oldest area in Balikpapan can be seen from the darkest area, since the area has been built from earliest period. Referring to the topographic data, the city built-up area in 1987-1996 mostly occupies the low-moderate slope level. As a hill city, where 85% of the areas are contoured, the urban development trends was tend to be influenced by the slope. Take an example, the east coast region with low slope rates is likely to be developed than the other part of the city. Based on historical data, the development pattern can be simplified by take a vivid line of the black shade area as the development direction. As seen in Figure 9, the growth pattern spreading from one zone on the southwest side, radiating outwards. Although it does not form a central pattern, it can be seen that the development trend of Balikpapan is dominated by infrastructure. Needless to say, in the context of Balikpapan City, the area to the southwest is a heritage area which start the growth. Organic pattern is formed by irregular shape of the block’s arrangement. This finding also supports the fact that Balikpapan has preserved its heritage area while trying to manage the sustainable urban form indicators. The form of urban heritage zone depicts the identity of the oldest establishment of the city as time goes by.

5. Conclusion
The role of the figure-ground map is essential to recognize the built-up zones in groups. In the large scale, the relationship between solid and voids is not seen individually in each building, but in a larger group of buildings and open spaces. Based on the mapping, identification of building-age can be used as basis information of the existence of a city centre; in this case, it referred to the finding of heritage zone and the growth orientation. This method helps researchers to investigate the focal point of growth in cities that are not formed by a distinctive indigenous characteristics or empire and leadership that influence the organization of cities. The things that happen to the city affect the shape of the built-up area configuration that shows a combination of various patterns. As mentioned in one study, growth trends in areas within the city structure are connect blocks and tend to be grid-shaped. Besides, tree-like form is also seen in the area of suburbs shaped like a radius along the street extension [17].

The developmental pattern is also seen through the process of studying the building age in the a blocks that appear before and after a certain period. The results of the identification can be an input for planning and predicting further urban growth. However, urban development cannot be seen only with a two-dimensional map. Other considerations that significantly determine the growth steps include physical conditions such as slope. In addition, this finding might lead to the further investigation about other related sustainable urban form indicators that will associate the city achievement to sustainable development.
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