FINDING THE CRAMPED SPACE IN A CITY: THE ACCESSIBILITY ASSESSMENT OF PONTIANAK CITY BASED ON THE GRIDDED POPULATION DENSITY

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Abstract. Recently, the data on population distribution only illustrates a number of density of a city or a district. Thus, it can not show the exact area of the crowded population. The population density in a city can cause a mismatch between the available space and the carrying capacity of its environment. The discrepancy can make it challenging to allocate resources or assistance in a disaster. In this regard, it is necessary to conduct research on the population's spatial distribution and the potential for movement between spatial segments. It is important to locate the cramped space where the space has high density but low accessibility in the city. This study aimed to determine the distribution of the population in the grid of 0.5 km and its assessment on accessibility in Pontianak City. The methodology used in this research is the population mapping method and space syntax. This research performs a quadrant mapping and correlation analysis to assess city accessibility. The result of the population distribution of Pontianak City shows the density concentrated in the city's center and dispersed from the river to inland. The quadrant maps show that Pontianak City has good accessibility. The quadrant map can be used as a recommendation for city development. With the quadrant division, the government can first concentrate its resources on repairing or developing the grid unit with low accessibility. With a coefficient correlation of 40.5 % and 50.9 %, this research found a positive and moderate correlation between density distribution and accessibility.

Keywords: Grid; Population; Accesibility; Space Syntax; Density

[Judul: Mencari Ruang Sempit Dalam Sebuah Kota: Penilaian Aksesibilitas Kota Pontianak Berdasarkan Kepadatan Penduduk Dalam Grid] *Dewasa ini, data distribusi populasi hanyalah sejumlah catatan kepadatan kota atau kabupaten. Data ini tidak menunjukkan area pasti dari populasi yang ramai. Kepadatan penduduk di suatu kota dapat menyebabkan ketidaksesuaian antara ruang yang tersedia dan daya dukung lingkungannya. Perbedaan yang terjadi dapat menyulitkan untuk mengalokasikan sumber daya atau bantuan jika terjadi bencana. Dalam hal ini, perlu dilakukan penelitian terkait distribusi spasial penduduk dan potensi pergerakan antar segmen spasial. Penting untuk menemukan ruang sempit di mana ruang yang memiliki kepadatan tinggi tetapi aksesibilitas rendah di kota. Penelitian ini bertujuan untuk mengetahui sebaran penduduk dalam grid 0,5 km dan penilaiannya terhadap aksesibilitas di Kota Pontianak. Metodologi yang digunakan dalam penelitian ini adalah metode pemetaan populasi dan space syntax. Penelitian ini melakukan pemetaan kuadran dan analisis korelasi sebagai penilaian akselisibilitas kota. Hasil sebaran penduduk Kota Pontianak menunjukkan kepadatan yang terkonsentrasi di pusat kota dan tersebar dari sungai ke pedalaman. Peta kuadran menunjukkan Kota Pontianak memiliki akselisibilitas yang baik. Peta kuadran dapat digunakan sebagai rekomendasi untuk pengembangan kota. Dengan pembagian kuadran, pemerintah dapat memusatkan sumber dayanya untuk memperbaiki atau mengembangkan unit jaringan dengan aksesibilitas yang rendah terlebih dahulu. Dengan korelasi koefisien sebesar 40,5% dan 50,9%, penelitian ini menemukan korelasi positif dan sedang antara distribusi densitas dan aksesibilitasnya.*

Kata Kunci: Grid; Populasi; Aksesibilitas; Space Syntax; Kepadatan

1. INTRODUCTION

Population growth continuously increases in direct proportion to the need for residential areas (Arief & Pigawati, 2015). In line with population growth, a city will grow in its development. The development of a city must consider the environment's capacity and efficiency in allocating resources and space (Indriastjario, 2018). In this regard, it is necessary to know the spatial distribution of the population in a city. Modeling the population distribution can support future study of a city or in other geographic scale (Nengsih, 2015). Nengsih explained that this was related to planning mandated by Law No. 4 of 2011 about Geospatial Information. Understanding the distribution of the population in the grid can be future investment in population development and planning to prevent unwanted things such as an exposure of natural disaster and social or economic crisis (Salvatore et al., 2005).

Grid population data proves necessary to inform emergencies and possible response efforts (TReNDS & SDSN, 2020). Several studies have been conducted related to the spatial population grid. The first research is a study conducted by Nengsih (2015) about the uneven distribution of the population in Indonesia and the population problems. This study uses a simulation or modeling method of GIS (Geographic information System). The results obtained are in the form of a population distribution model in the territory of Indonesia. The second research is research conducted by (Dulal & Thomas, 2014). This research is based on the importance of up-to-date and accurate population data. This study uses a methodology that transforms population census data into data with higher resolution accuracy to achieve its objectives. For this reason, population census data will be made in a grid with a range of 100 meters. The results of this population grid are then compared with the LandScan global dataset. The third research is a study conducted by Leyk et al. (2019). This research is based on the importance of population data as a basis for studies that focus on the relationship between humans and nature, disasters, and environmental health. This study fills the gap and compares and discusses large-scale data related to gridded datasets representing population size and density.

The focus of the research is more on the variety of data, the methodological approach used, and the quality aspects among research-related matters to fully understand the characteristics of the existing data.

Research related to spatial population grids has also been carried out by Tobler, Deichmann, Gottsegen, and Maloy (1997). This research is based on the importance of population data presented in a sub-national to determine a pattern of cells on the earth. This research uses satellites as a tool to collect data that are arranged based on latitude and longitude. The result of the research is a world boundary based on coordinates along with estimated population size. This research can be useful for the analysis of future studies. This spatial population distribution data set was built to support various needs such as measuring the impact of population growth, distance to clean water, estimating populations at risk, studying the epidemic spread and population persistence (Dong, Yang, Cai, & Xu, 2017).

Different from previous studies that stopped at the results of the population grid map, this study assesses the results of the population grid. There is no indicator about how dense an environment should be. A city can be as crowd as it can but the other aspect like accessibility affect the quality of the city. For example, Ušpalyte-Vitkūniene and Burinskiene (2006), found that the relationship between population density and the accessibility affects the house pricing. Therefore, this research is assessing the gridded population density with its accessibility to measure it quality. The accessibilty data is based on the space syntax analysis. Space syntax is a method for spatial analyzing (Hillier & Hanson, 1989). This research use space syntax analysis, the integration analysis to measure the accessibility of the city route. Integration analysis determines spatial integration or the relationship between existing road segments (Matějček &

Přibyl, 2020). Integration can be defined as the potential for movement or how easy it is to reach a spatial segment from another segment as measured by mathematical 'closeness' (Hillier & Stonor, 2010).

Pontianak City is the most populous city in West Kalimantan Province, with a density of 5,567 people/km and total population 658,685 people (BPS Kota Pontianak, 2021). Pontianak city is located on the equator and has peatland (Sarwono, 2011). The environment of Pontianak makes it prone to disasters, especially fire and flood disasters. A large number of residents in Pontianak City causes traffic jams to the point where there is a buildup in the connecting lanes separated by rivers and light traffic jams on several roads (Masudi, Alwi, & Rustamaji, 2017). This congestion can cause delays in aid in the event of a disaster. The existing conditions and problems make Pontianak City a critical object to study regarding the distribution of the human population in the grid and its integration value. The purpose of this research is to assess the accessibility of Pontianak City by density distribution in the grid and its relationship with the integration value associated with the density distribution and accessibility of the city. Identifying the capabilities of environmental infrastructure in dealing with disasters can reduce the risk of catastrophe so that they can minimize losses due to the occurrence of the disaster itself (Findia, 2020). Likewise, this research is expected to be helpful in reducing losses through density mapping and accessibility analysis in Pontianak City.

1.1. Gridded Population

Gridded population is a population distribution proportional to the size of the estimated accessibility index for each unit cell (Salvatore et al., 2005). In the past, population mapping usually required population statistical relationships associated with "feature vectors", such as points (e.g., geographic coordinates denoting the center of a city) and polygons (especially administrative units or census enumeration areas) (Leyk et al., 2019). Furthermore, Leyk et al. (2019) explained that the impetus for the formation of grid population data emerged after Roger Tomlinson

developed the first GIS software. The research community began to use various biophysical and geophysical data products in the grid.

With the gridding population, researchers can more easily integrate population numbers and density data with biophysical data to understand better the socio-environmental system's spatial distribution and components (Leyk et al., 2019). In addition to its compatibility with environmental information, the grid population data format has considerable advantages for analytical studies. Researchers can convert the data to alternative formats with relative ease (Tobler et al., 1997). Knowing the distribution of the population in the grid can be future investment in population development and planning to prevent unwanted things (Salvatore et al., 2005).

Currently, urban planning leads to the concept of a resilient city. A resilient city is an effort to develop a capacity to help absorb future shocks and emphasize social, economic, and technical systems and infrastructure so that they can maintain the same functions, structures, systems, and identities (Ariyaningsih, Erik, & Sukmara, 2021). Cities with the concept of a resilient city can anticipate and reduce the consequences of disasters. By incorporating monitoring and early warning technologies, a resilient city can protect infrastructure, community, and individual assets, including their homes and property, cultural heritage, the environmental and economic capital. A resilient city can also minimize physical injury (Shafira, Kautsary, Widyasamratri, & Rahman, 2020). The grid data collection on the population (spatially) will significantly help apply the resilient city concept. This is because spatially distributed population data can support various needs such as measuring the impact of population growth, distance to clean water, estimating populations at risk, studying the epidemic spread, and population persistence (Dong et al., 2017).

1.2. Space Syntax

Space syntax is a method for scientific modeling of cities (Hillier & Stonor, 2010). Space syntax is a method or technique for displaying, predicting, calculating, or measuring a configuration of space

and analyzing and defining it (Hillier & Hanson, 1989). Space syntax provides accuracy by referring to spatial concepts and various analytical techniques that can describe the spatial features of a sustainable city (Claudia, van Nes, & Garau, 2021). In his paper, Claudia et al. (2021) explain that the first approach to the space syntax method dates back to the 1970s. Over the years, Bill Hillier and his colleagues developed the space syntax at University College London, and it has been applied in urban studies since the 1980s (Nes & Yamu, 2017).

The advantage of space syntax is that it provides scalable results to be used in configuration analysis in both small and large ranges. Therefore, space syntax has the potential for use in urban design, where space syntax can help optimize zoning plans and identify potential risks (Matějček & Přibyl, 2020). In this regard, Jiang and Claramunt (2002) explain that space syntax can provide a computational representation of urban space through a graphical decomposition of free space, namely the space where humans can move from one place to another in the city (model cognitive space). This method provides a set of parameters that allow scientists to understand the function and nature of the urban structure (city morphology).

Space syntax has several types of analysis, one of which is integration analysis. Integration is one of the essential measurements in space syntax because, with this analysis, space configuration can be seen as a system (Puspitasari, 2020). Syntactic integration can be defined as the potential for movement or how easy it is to reach a spatial segment from another segment as measured by mathematical 'closeness' (Hillier & Stonor, 2010). In other words, integration analysis can find out how the relationship and overall spatial arrangement will affect the level of accessibility of the space (Pramudito, Cahyandari, & Surya, 2017).

2. METHODS

This research uses a quantitive approach and grounded theory analysis to synthesis a conclusion. The main question of this research is about the interrelation between accessibility and population density in a grid. To answer that, this research was conducted in two parallel sub-task (Figure 1). The first task is to determine the distribution of population in the grid. This task is conducted by simple counting of thousand buildings mass in Pontianak City. The second task is to analyze the accessibility of the city route by space syntax analysis integration. Hence both of the tasks are a quantitative approach. The result of those tasks is data for quadrant mapping and partial correlation analysis. This research uses a colored representative graphic in a particular range to communicate the information data in friendly ways.

This research use CAD software (AutoCAD) in modeling and counting the building count and building area. The counting are performed by simply selecting building in an unit of grid. The information appears in the properties menu of the software. Hence the building are modellled as polyline, the properties menu will show how many polyline in the selection, in this case the grid. The area of buildings are obtained by using AutoCAD custom function by Mac (2015) (see Appendix 1). Both data of building area and building count are converted to people per grid by using Equation 1. People per grid (p) are defined as the fraction of total building area in grid (A) by total building area in the city (∑A) times total population in the city (Equation 1). Similar to Equation 1, building count (n) in Equation 2 are also act as the fraction of population distribution.

$$p = \frac{A}{\sum A} \times \sum P \qquad (1)$$

$$p = \frac{n}{\sum n} \times \sum P \qquad (2)$$

The object of this research is Pontianak City in Indonesia. The city is located on the equator with a hot and humid climate. The geography of Pontianak city has two river crossings in the middle of the city, forming a rotated Y shape. The rivers separated Pontianak City into three lands. Each land becomes a district except the largest one separated into four districts. So, Pontianak has six districts (Figure 2). To access across the rivers, there are two bridges and a ferry for rivers crossing service. Pontianak city is the most populated city in West Kalimantan Province. The density is 5,567

people/km, with a total population of 658,685 people (BPS Kota Pontianak, 2021).

The global standard or population data resolution for grid size is thirty arc-seconds or 1 km (Doxsey-Whitfield et al., 2015). The grid size in this research is set at 0.5 km. This size is twice more detail than the standard. With this size, the city area is divided into 484 grid units. The actual area of Pontianak City is 118.31 km2, but due to the grid cut, the size of the object expanded to 121 km2. To ease the mapping of the density, each grid is named with an alphabet and numbers (Figure 3).
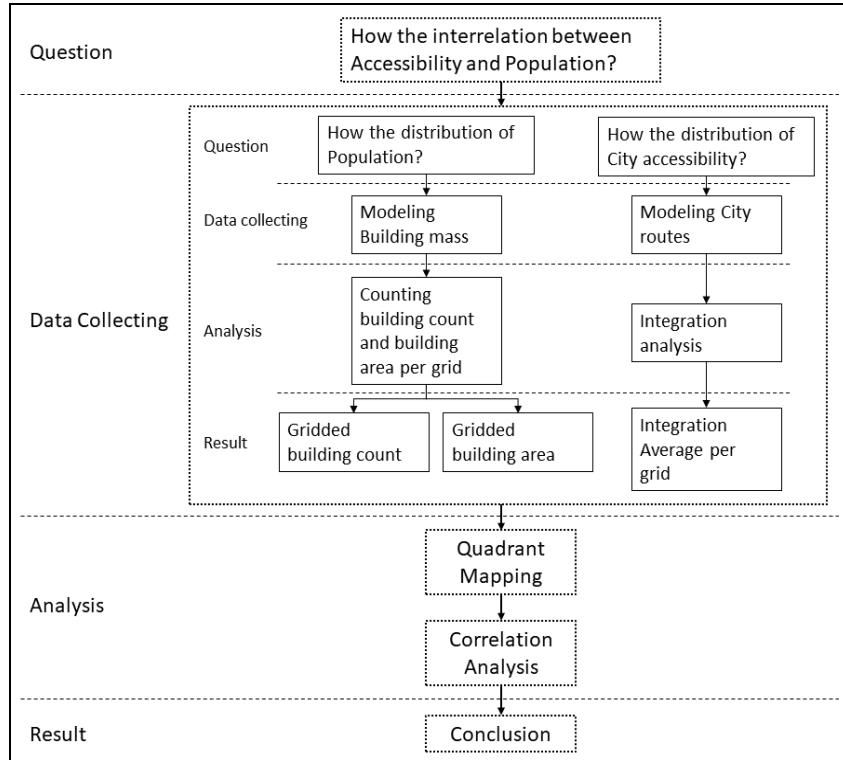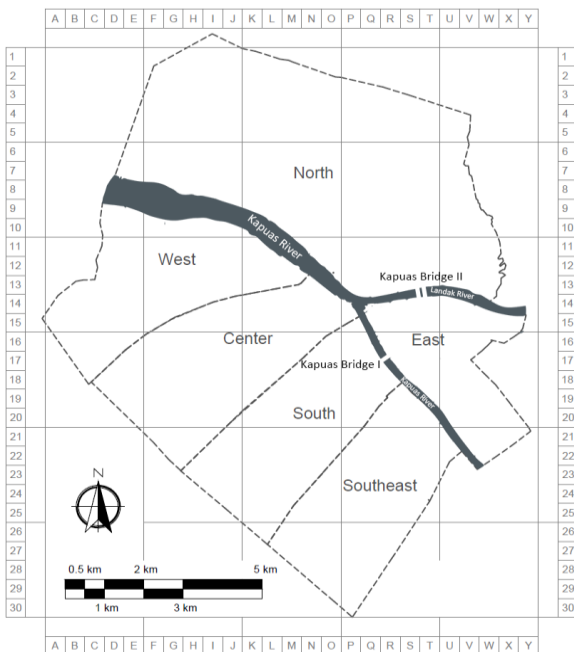

Figure 1. Research Process

Figure 2. Pontianak City Districts, Rivers, and Bridges
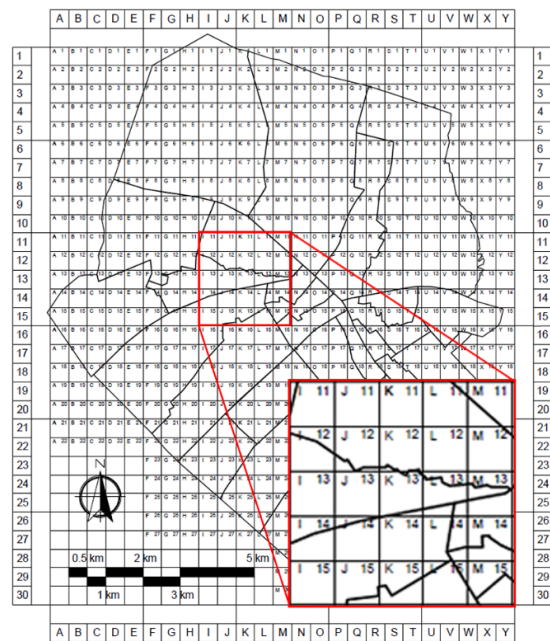

Figure 3. Dividing and Naming the Grid of Pontianak City

3. RESULT AND DISCUSSION

3.1. Population of Pontianak City in Grid

In this research, the population density is based on the building count of the city and the building area. This research assumes the building represent the settlement of people. The building data is retrieved from open street map base using cadmapper website. The total building mass in Pontianak City is 157,557 buildings with a total area of 19,913,492 m2 (Figure 3). People density based on building count mostly represents how many household or familiy in Pontianak city. Many buildings in Pontianak City are adjacent to each other and share the same wall such as shophouse. This arrangement make couple or several building counted as one building mass in open street map data. To validate that error, this research use another method to count the people density which is based on building area. Counting by building area represent the distribution of people evenly in the buildings of a grid.

Figure 4. Building Mass of Pontianak City

The result of the population distribution based on building area and building count show different color distribution. Both density grid maps show the same dense spot but with different ammount. Both maps mark grid I-11 as the hotspot. Population distribution based on building mass are distributed more evenly then by building count. Most grids near river are denser. The density gradually turn lighter as the grid far away from the river. Based on these maps, the most populated district is West Pontianak followed by Center

Pontianak. The least populated district is West Pontianak and the second least is Souteast Pontianak.
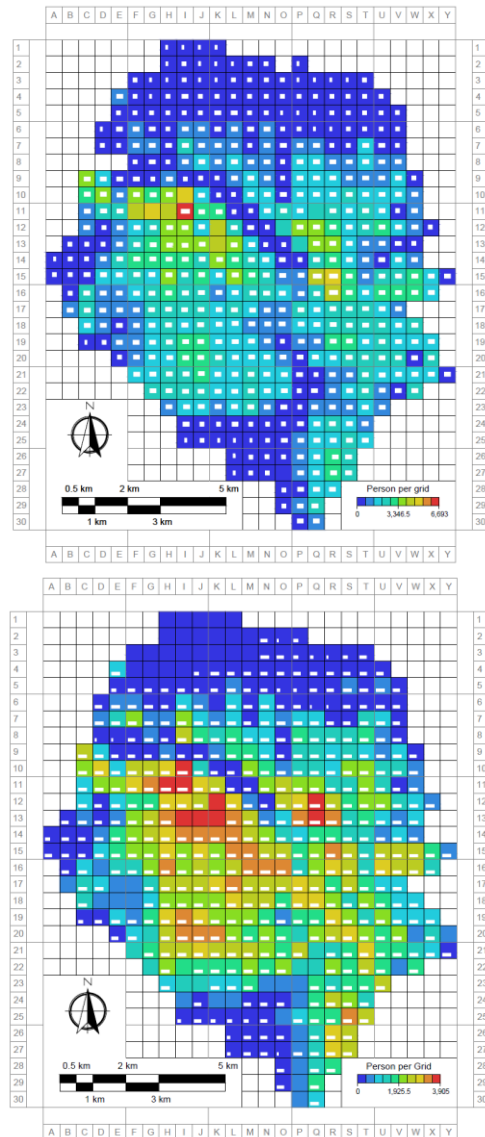

Figure 5. The gridded population of Pontianak City based on Building Area (above) and The gridded population of Pontianak City based on Building Count (bottom)

3.2. Integration of Pontianak City in Grid

Integration analysis is spatial calculation of accessibility. Actually by this analysis, this research can achieve the accesibility assesment of Pontianak city. But this research try to combine the population distribution as a variable and make the assesment more advance. This research using computer software depthmapX version 0.50 to perform integration analysis. The integration analysis can be performed manually without computer assistance by using equation 3 and 4.

These equation is found by Hillier and Hanson (1989) in the book of Social logic of space. The equation contain of three variable, where Dk is D-value, n stand for total route segment, and TD stands for total depth. Total depth is sum of all access deepness value of any route segment to all other segments in the city route system.

$$i = \frac{D_k(n-2)}{2\left(\frac{TD}{(n-1)}-1\right)} \quad (3)$$

$$D_k = \frac{2\left[n\left(log_2\left(\left(\frac{n+2}{3}\right)-1\right)\right)+1\right)}{(n-1)(n-2)} \quad (4)$$

The route system of Pontianak City is refered to the bridges, roads, and alleys (Figure 6). The data is retrived from open street map database. The administration line of Pontianak City does not limit the route system. In fact, to get more realtime result, this research use radius of 9 km to retain the route system scope. The routes outside Pontianak City are also included in the integration analysis. But later when compiling data, the result only take the integration data inside Pontianak City.

The result of the integration analysis show a concentric model of accessibility (Figure 7). South Pontianak has the most integrated route with integration value ranged from 0.660 to 0.734 while the average integration is 0.510. The most segregrated route are distributed in North Pontianak. Earlier in figure 5, North Pontianak are less populated. So the segregrated routes will not be an issue while there are less people using it.
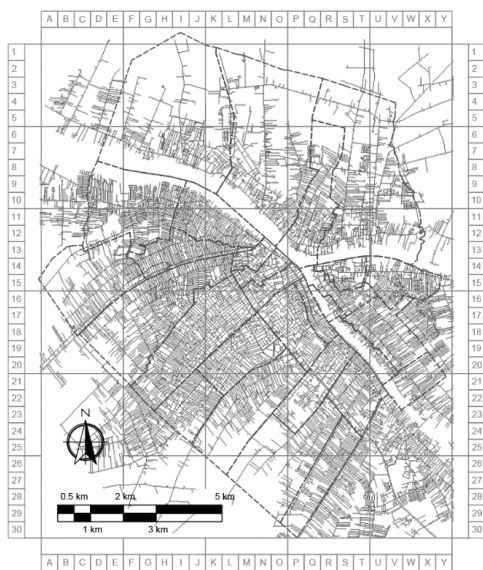

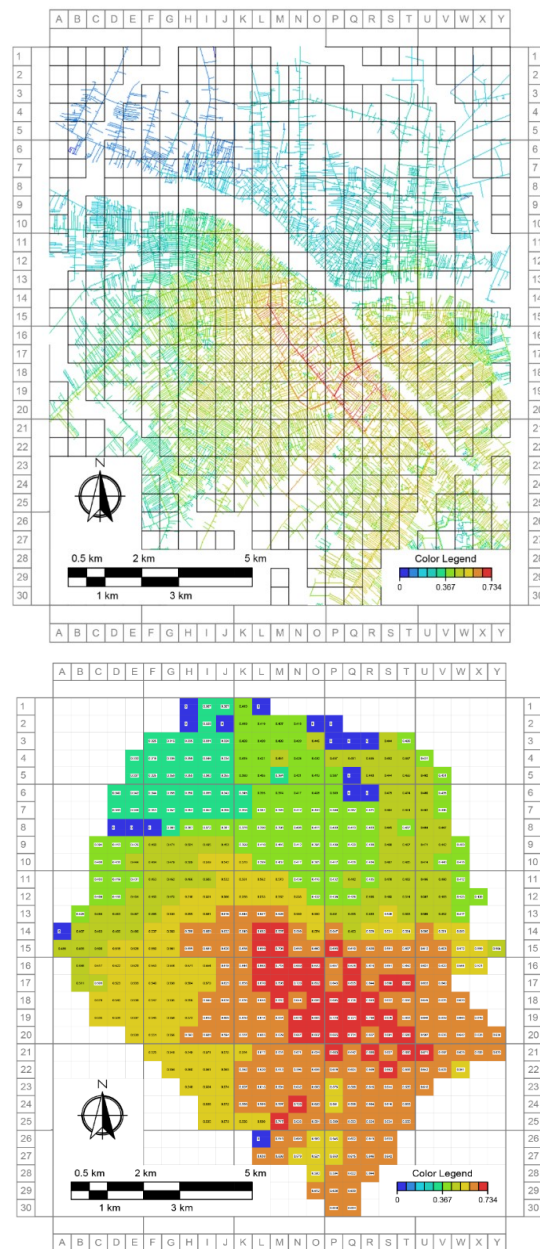**Figure 6.** Routes of Pontianak City

Figure 7. Integration Analysis of Pontianak City (above) and The Gridded Integration Analysis of Pontianak City (bottom)

3.3. Correlation and Quadrant Map of Population Density and Integration

The purpose of quadrant mapping is to indicate the accessibility level of each grid unit. As usual, the quadrant has four division (quadrant 1st, quadrant 2nd, quadrant 3rd, quadrant 4th). Each quadrant represents a condition of the accessibility level (high, moderate, and low). The logic of the quadrant is based on the density and integration data. If the density is higher than its median, the accessibility is likely to be a crowded and potential traffic jam. If the integration is higher than the

median, the accessibility is high and easy. By both of this logic, this research assigns the accessibility level of each quadrant as follows: quadrant 1st (Q1) has moderate accessibility level; quadrant 2nd (Q2) has high accessibility level; quadrant 3rd (Q3) has moderate accessibility level, and; quadrant 4th (Q4) has low accessibility level.
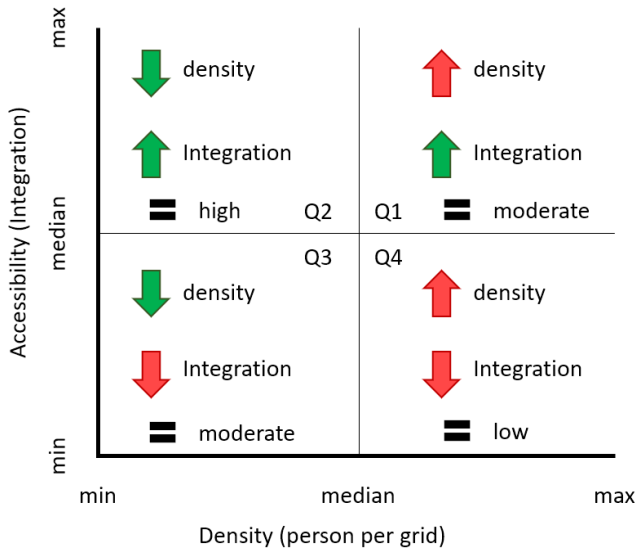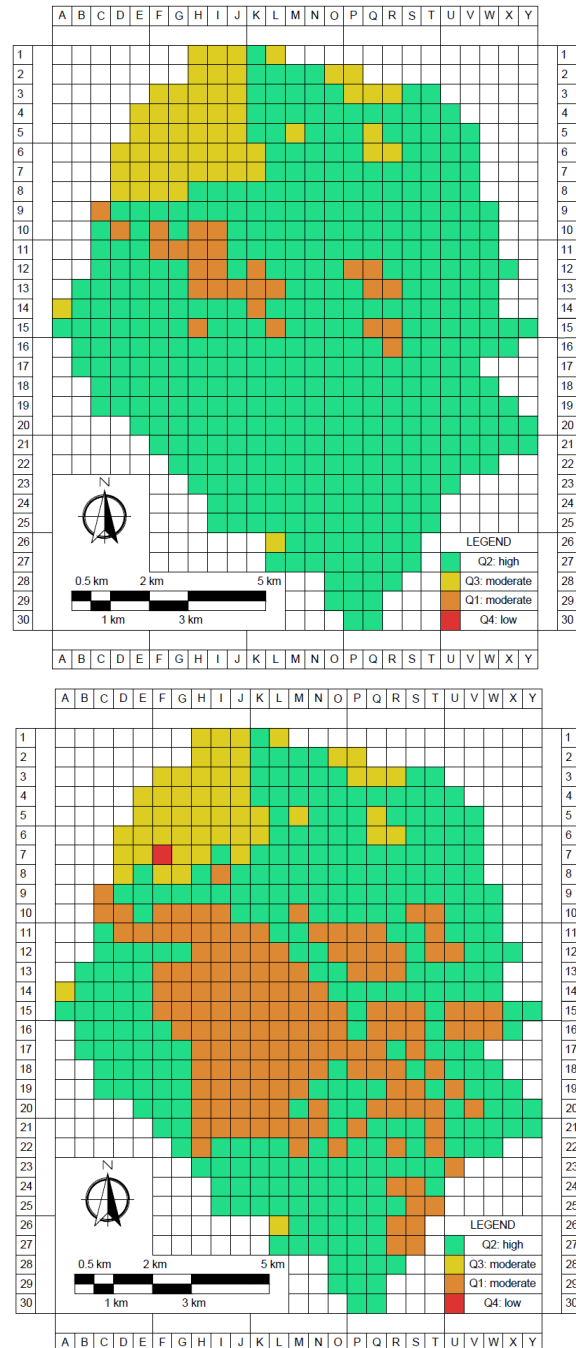

Figure 8. The Logic of Accessibility Assessment Quadrant

Because there are two methods in density population distribution analysis. This research perform two quadrant map. One based on building count (Figure 9 Left) and the other based on building area (Figure 9 Right). As result, both quadrant maps show different analysis. Based on building count, most grid has high accessibility level or on quadrant two. Several grid units on the rear of the map has moderate level of accesibility because of the segregated integration value. The rest of the grid units are located on the center of the map or near the rivers and they have moderate level of accesibility because of high population. Meanwhile, the quadrant map based on building area has quite similar result but there are more moderate grid units and there is one low accessibility grid unit.

This research performs a partial correlation between density distribution and integration value to find out the relation between these two variable. As the result, the coeficient correlation between population distribution based on building count and integration of city routes is 40.5 % (Figure 10). While the coeficient correlation between population distribution based on building area and integration of city routes is 50.9 %

(Figure 10). Both coeficient indicate a positive and moderate level of correlation between those couple variable (Ratner, 2009). The pattern of scatter plots reflect the more populated space has better accessibility. This could means infrastructure with more population using it are more develop or the population growing because of the area are easy to access.

Figure 9. Quadrant Map of Accessibility assessment by comparing Building Count data and Integration data (above) and Quadrant Map of Accessibility assessment by comparing Building Area data and Integration data (bottom)
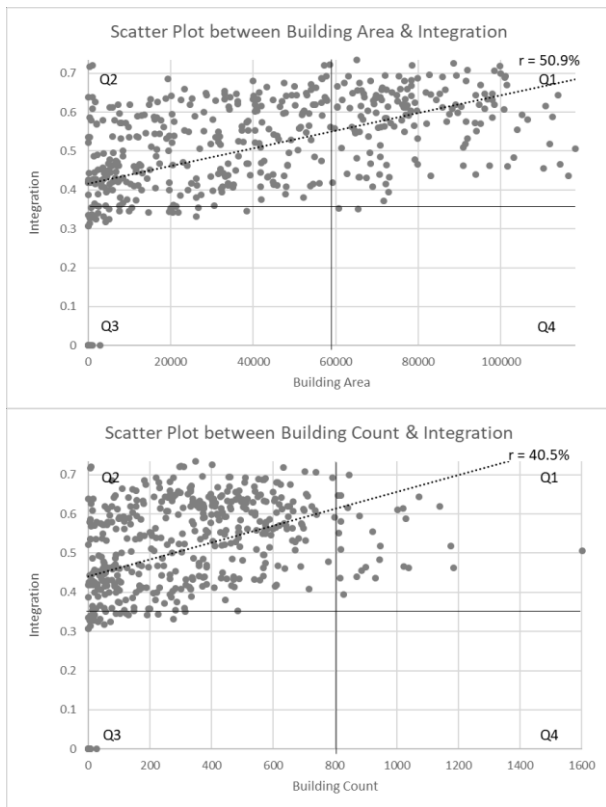
Figure 10. Scatter plot between Building Area and Integration (Above) and Scatter plot between Building Count and Integration (Bottom)

4. CONCLUSION

Knowing the exact population distribution of a city help us in planning and encountering urban disasters. This research makes more detail gridded population map for accessibility assessment. The result of population distribution of Pontianak City shows detail of population distribution. The density grid reflects the concentration of density dispersed from the river to inland. The quadrant maps show Pontianak City has good accesibility. The quadrant map can be used as reccomendation for city development. With the quadrant division, the government can concentrated their resources to repair or develop the grid unit with low accessibility first. For example, there is one grid units with low accesibility result. This grid unit is far from the center of the city but has high population density. With coeficient correlation of 40.5 % and 50.9 %, this research found a positive and moderate correlation between density distribution and its accessibility.

This research is merely a data of population distribution and accessibility distribution of Pontianak City. There are plenty analysis that can

be applied the this data. This data makes posible to run a disaster analysis to find out its impact to Pontianak City or planning a mitigation scenario in Pontianak

5. REFERENCES

Arief, M., & Pigawati, B. (2015). Kajian Kerentanan di Kawasan Permukiman Rawan Bencana Kecamatan Semarang Barat, Kota Semarang. *Teknik PWK (Perencanaan Wilayah Kota), 4*(2), 332-344.

Ariyaningsih, A., Erik, B., & Sukmara, B. (2021). Kriteria ketahanan kota berdasarkan jenis bencana prioritas di Kota Balikpapan. *Region: Jurnal Pembangunan Wilayah dan Perencanaan Partisipatif, 16*(1), 74-82. doi: https://doi.org/10.20961/region.v16i1.44149

BPS Kota Pontianak. (2021). *Kota Pontianak Dalam Angka (Pontianak Municipality in Figures) 2021*. Pontianak: BPS Kota Pontianak.

Claudia, Y., van Nes, A., & Garau, C. (2021). Bill Hillier's Legacy: Space Syntax—A Synopsis of Basic Concepts, Measures, and Empirical Application. *Sustainability (Switzerland), 13*(6). doi: https://doi.org/10.3390/su13063394

Dong, N., Yang, X., Cai, H., & Xu, F. (2017). Research on Grid Size Suitability of Gridded Population Distribution in Urban Area: A Case Study in Urban Area of Xuanzhou district, China. *PloS one, 12*(1), e0170830. doi: https://doi.org/10.1371/journal.pone.0170830

Doxsey-Whitfield, E., MacManus, K., Adamo, S. B., Pistolesi, L., Squires, J., Borkovska, O., & Baptista, S. R. (2015). Taking Advantage of the Improved Availability of Census Data: A First Look at the Gridded Population of the World, Version 4. *Papers in Applied Geography, 1*(3), 226-234. doi: 10.1080/23754931.2015.1014272

Dulal, C. R., & Thomas, B. (2014). A Grid-Based Approach for Refining Population Data in Rural Areas. *Journal of Geography and Regional Planning, 7*(3), 47-57. doi: https://doi.org/10.5897/jgrp2013.0409

Findia, F. (2020). Kemampuan Prasarana Lingkungan Terhadap Bencana Pada Kawasan Permukiman Padat Penduduk di

Kelurahan Pelita, Kota Samarinda. *Jurnal Ilmiah MITSU (Media Informasi Teknik Sipil Universitas Wiraraja), 8*(2), 107-114. doi: https://doi.org/10.24929/ft.v8i2.985

Hillier, B., & Hanson, J. (1989). *The Social Logic of Space*. Cambridge: Cambridge University Press.

Hillier, B., & Stonor, T. (2010). *Space Syntax - Strategic Urban Design*: Future of Urban Space and Humanity.

Indriastjario, I. (2018). Kajian Konsep Resilient Design Untuk Pengembangan Kawasan Waduk Jatibarang Kota Semarang. *MODUL, 18*(1), 41-45. doi: https://doi.org/10.14710/mdl.18.1.2018.41-45

Jiang, B., & Claramunt, C. (2002). Integration of Space Syntax Into GIS: New Perspectives for Urban Morphology. *Transactions in GIS, 6*(3), 295-309. doi: https://doi.org/10.1111/1467-9671.00112

Leyk, S., Gaughan, A., Adamo, S., de Sherbinin, A., Balk, D., Freire, S., . . . Tatem, A. (2019). Allocating People to Pixels: A Review of Large-Scale Gridded Population Data Products and Their Fitness For Use. *Earth Syst Sci Data Discuss*, 1-30. doi: https://doi.org/10.5194/essd-2019-82

Masudi, H., Alwi, A., & Rustamaji, R. (2017). Kajian Tingkat Kejenuhan Lalu Lintas Pada Jembatan Kapuas I di Kota Pontianak. *Jurnal Teknik Sipil, 17*(1). doi: http://dx.doi.org/10.26418/jtsft.v17i1.23873

Matějček, J., & Přibyl, O. (2020). *Space Syntax: A Multi-Disciplinary Tool to Understand City Dynamics.* Paper presented at the 2020 Smart City Symposium Prague (SCSP).

Nengsih, S. R. (2015). Pembangunan Model Distribusi Populasi Penduduk Resolusi Tinggi Untuk Wilayah Indonesia Menggunakan Sistem Grid Skala Ragam. *GEOMATIKA, 21*(1), 31-36.

Nes, A. V., & Yamu, C. (2017). Space Syntax: A method to measure urban space related to social, economic and cognitive factors *The virtual and the real in planning and urban design* (pp. 136-150): Routledge.

Pramudito, S., Cahyandari, G. O. I., & Surya, V. R. V. (2017). *Analisis VGA: Sebuah Pendekatan untuk Membaca Nilai Integrasi Ruang pada Bangunan Ndalem Joyokusuman Yogyakarta*. Paper presented at the Seminar Ikatan Peneliti Lingkungan Binaan Indonesia (IPLBI) 1, B 185-192.

Puspitasari, C. (2020). Metode Analisis Space Syntax Pada Penelitian Interaksi Kota Multibudaya. *Lakar: Jurnal Arsitektur, 3*(01), 36–44. doi: 10.30998/lja.v3i01.5879

Ratner, B. (2009). The Correlation Coefficient: its Values Range Between +1/−1, or do They? *Journal of Targeting, Measurement and Analysis for Marketing, 17*(2), 139-142. doi: 10.1057/jt.2009.5

Salvatore, M., Pozzi, F., Ataman, E., Huddleston, B., Bloise, M., Balk, D., . . . Yetman, G. (2005). *Mapping Global Urban and Rural Population Distributions*. Italy Environment and Natural Resources Service, FAO.

Sarwono, A. (2011). Peningkatan Layanan Institusi Pemadam Kebakaran Melalui Penerapan Rencana Induk Kebakaran (RIK) Studi Kasus: Kota Pontianak Kalimantan Barat. *Jurnal Permukiman, 6*(2), 58-66.

Shafira, S., Kautsary, J., Widyasamratri, H., & Rahman, B. (2020). Evaluasi Penerapan Kategori dan Tujuan Kota Tangguh Pada Dokumen Kebijakan Strategi Ketahanan Kota 100 Resilient City. *Pondasi, 25*(2), 120-136. doi: http://dx.doi.org/10.30659/pondasi.v25i2.13039

Tobler, W., Deichmann, U., Gottsegen, J., & Maloy, K. (1997). World Population in A Grid of Spherical Quadrilaterals. *International Journal of Population Geography, 3*(3), 203-225. doi: https://doi.org/10.1002/(SICI)1099-1220(199709)3:3%3C203::AID-IJPG68%3E3.0.CO;2-C

TReNDS, & SDSN. (2020). Leaving No One Off The Map: A Guide for Gridded Population Data for Sustainable Development. from https://www.unsdsn.org/leaving-no-one-off-the-map-a-guide-for-gridded-population-data-for-sustainable-development

Ušpalyte-Vitkūniene, R., & Burinskiene, M. (2006). Analysis of The Dynamics of Walking Distances to Public Transport Routes and its Influence on Housing Prices. *Journal of Civil Engineering and Management, 12*(3), 261-267. doi: 10.1080/13923730.2006.9636401