

From Thousand Canals to Roads: The Transformation of Transportation Mode in Pontianak

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Abstract. Pontianak City was established in 1771 on the the Kapuas River and Landak River riverbanks, the latter being the longest river in Indonesia. The city was once known as the City of a Thousand Canals. However, in its development, people shifted to land transportation modes, leaving the canals in an extinction process. This study aimed to uncover the factors and impacts of the inland water transportation network fading from the Pontianak urban structure. The research used a sequential explanatory design, combining qualitative methods in the form of literature review and quantitative methods using space syntax analysis. By comparing the spatial configuration of the canals and roads in a diachronic approach, the study found proof of the importance of the canals' existence in the Pontianak urban structure. Water transportation can be the answer to fixing environmental issues, flood hazards, and traffic congestion. Revitalizing the canals can help bring a healthy water environment because the people will change their perception of the canals from sewage routes to transportation routes. Revitalizing the canals can also bring back waterside activity, generate a sense of belonging, and bring back part of the former identity of Pontianak City.

Keywords. Riverside city, space syntax, spatial analysis, urban morphology, water transportation.

Abstrak. Kota Pontianak didirikan pada tahun 1771 di tepi Sungai Kapuas dan Sungai Landak,, yang terakhir merupakan sungai terpanjang di Indonesia. Kota ini dulunya dikenal dengan sebutan Kota Seribu Parit. Namun dalam perkembangannya, masyarakat beralih ke moda transportasi darat sehingga parit-parit tersebut mengalami proses kepunahan. Penelitian ini bertujuan untuk mengungkap faktor dan dampak memudarnya jaringan transportasi perairan darat dari struktur perkotaan Pontianak. Penelitian ini menggunakan desain eksplanatori sekuensial, memadukan metode kualitatif berupa tinjauan pustaka dan metode kuantitatif dengan menggunakan analisis sintaksis ruang. Dengan membandingkan konfigurasi spasial parit dan jalan melalui pendekatan diakronis, penelitian ini menemukan bukti pentingnya keberadaan parit dalam struktur perkotaan Pontianak. Transportasi air dapat menjadi jawaban untuk mengatasi permasalahan lingkungan, bahaya banjir, dan kemacetan lalu lintas. Revitalisasi saluran dapat membantu mewujudkan lingkungan air yang sehat karena masyarakat akan mengubah persepsi mereka terhadap parit dari jalur pembuangan limbah menjadi jalur transportasi. Revitalisasi parit juga dapat mengembalikan aktivitas tepi sungai, membangkitkan rasa memiliki, dan mengembalikan sebagian identitas Kota Pontianak sebelumnya.

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Kata kunci. *Analisis spasial, kota tepi sungai, morfologi perkotaan, sintaksis ruang, transportasi air.*

Introduction

Pontianak City was the last kingdom in West Kalimantan in the kingdom era (Nurcahyani et al., 1999). Today, Pontianak is the economic and governmental center of West Kalimantan Province. About 250 years ago, the area was a forest crossed by the Kapuas River, the longest river in Indonesia. Currently, the city has become the capital and the most populous city of West Kalimantan province due to its strategic location in the water environment (Gunawan et al., 2022). The density of the city reaches 6110 people per km² and is sixty times denser than the surrounding areas (BPS West Kalimantan Province, 2022). At the beginning of its development, the people of Pontianak actively carried out social and economic activities on the river and canals. Because of this, Pontianak was once called the City of a Thousand Canals (Saputra, 2021). However, this activity disappeared quickly after the popularization of land transportation modes. Because of this change some of the existing canals in Pontianak City were covered by pavement and roads, overgrown with aquatic plants, or turned into trenches (Hadrian, 2017). Still, some canals have managed to survive (see Figure 1).

Pontianak is, like other urban areas, undergoing a continuous transformation over time. Roads, plots, and buildings as part of the city's skeleton can predict the transformation. Canals and other water transportation routes can be seen as the skeleton of water transportation. For example, Crompton and Brown (2007) proposed the idea of a double fractal structure in Venice because the roads and canals coexist in forming the city. The urban structure concept is based on seeing the city as a geometric configuration that is the product of socio-spatial transformation (Wardhani & Bahri, 2020). A previous study by Lv and Tang (2019) uncovered a relationship between development in ancient times and the water network of Keqiao, an ancient town in China. Meanwhile, Yun and Liu (2023) utilized the spatial configuration of the water network in Suzhou, China to analyze the distribution of gardens in this city. Additionally, Hassan et al. (2022) discovered that studying social and political history and conducting visual observations through maps of various historical periods can shed light on the spatial configuration and urban fabric. The present study may help to recapture lost knowledge or culture that could guide a valuable urban planning and design approach (Hassan et al., 2022). Gaining insight into the evolving infrastructure and morphology of Pontianak City over time can enhance our understanding of how to address urban challenges and achieve sustainable cities and communities.

This research can be categorized as a qualitative analysis study and mixed qualitative and quantitative analysis study. The qualitative analysis used observation to recognize the spatial pattern of Pontianak City based on urban morphological theory. Eight previous pieces of research about the urban morphology of Pontianak were carefully consulted in this study. Of course, various approaches have been applied in these previous studies. Destria and Wibisono (2012) used a descriptive synchronic and diachronic study. Nurharahman and Syaodih (2017) and Bayu and Susanto (2013) used pattern observation from the figure-ground of Pontianak City. Nurhidayati and Arianti (2021) compared the satellite view of the built environment in Pontianak to visualize the city's expansion.

A weakness of qualitative analysis is the absence of quantitative data or statistical evidence. The second study category is a set of methods that combine observation with quantitative spatial analysis and space syntax. All four space syntax pieces of research conducted by Gultom et al. (2022a; 2022b), Gunawan et al. (2022), and Jati et al. (2021) were limited to the road network as spatial configuration. The present study used both configurations of canals and roads, viewing

Pontianak as a double fractal city. By combining both perspectives, this study aimed to uncover the factors and impacts of the inland water transportation network fading from the Pontianak urban structure.

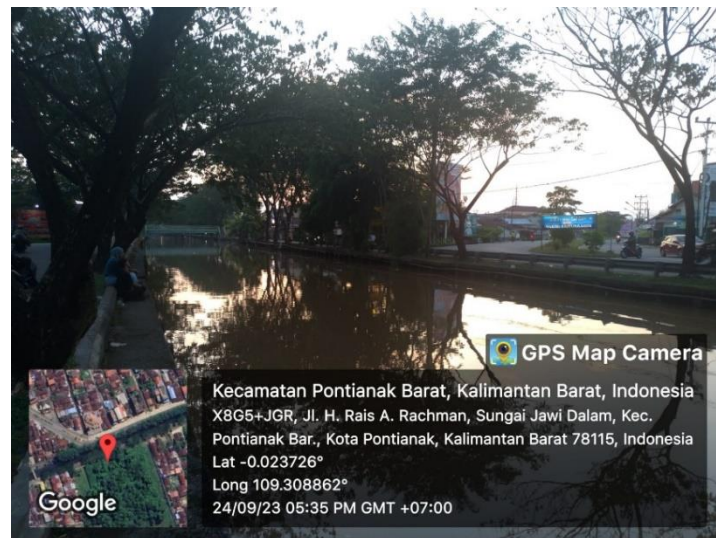


Figure 1. Current situation of Sungai Jawi Canal, one of the oldest canals in Pontianak.

Method

This paper conveys the factors that cause the phenomenon of people in Pontianak shifting from water transportation to land transportation by diachronic study. The study used six timeframes, i.e., the first period (before 1771 to 1771), the second period (1771 to 1855), the third period (1855 to 1895), the fourth period (1895 to 1967), the fifth period (1967 to 1983), and the sixth period (1983 to 2020). Each time frame represents a pivotal moment in the development of Pontianak.

The first period is marked by the emergence of early settlements, while the second period presents the establishment of the canal system. The third period shows the city's development under full control of the Dutch colonial government. In the fourth period, early urbanization took place, leading to the fifth period's significant shift towards land transportation. Finally, the sixth period represents the modern age of Pontianak.

The research method involved gathering historical literature about Pontianak, examining economic, political, and social factors relevant to transportation and the urban condition of Pontianak during specific periods. The literature itself is not enough to cover the question about the factors, so this research utilized a sequential explanatory method by conducting a quantitative method using space syntax analysis. Qualitative analysis is a tool to explain the literature review while the quantitative analysis gives a piece of solid evidence to support the findings.

The qualitative data used was literature in the form of journal articles, books, theses, news, and websites. All these types of literature were filtered by keywords, i.e., 'transportation', 'environment', 'history', 'urban morphology', and 'settlement development', related to Pontianak and its canals. The quantitative data was obtained by compiling old maps. The maps were remodeled using computer-aided design (CAD) into a 2D axial network map. A spatial analysis

tool, space syntax, was used to analyze the network maps from the six periods into an integrated graph.

Space syntax is a method proposed by Hillier and Hanson as a tool for analyzing any kind of spatial configuration and is popularly used in urban morphological studies (Hillier & Hanson, 1984). Space syntax has a set of mathematical equations, but the origin of space syntax is a real relative asymmetrical equation that indicates the main frame of a spatial configuration. This equation is often called an integration analysis. If the network of a city has a hypothetical symmetrical grid shape, it is easy to find out that the center or the frame of the city is the road in the middle (see Figure 2 on the left). But when the network has an asymmetrical shape, as found in most cities in real life, it is hard to find which segment acts as the main center of the city (see Figure 2 on the right). This is why an integration analysis is necessary. Figure 2 shows the differences in integration between a hypothetical symmetrical city and a segment of Budapest's inner circle. People can easily predict the center of a symmetrical city, which consists of the roads crossing in the middle. However, the center of the Budapest inner ring unpredictably lies on the ring roads, not in the middle. Knowing the center of a city can help to analyze where the main activity happens in the city. The highest integration segment will usually play the role of central business district (CBD). In a morphological study, high integration segments show the growing direction, orientation, and prediction for upcoming changes.

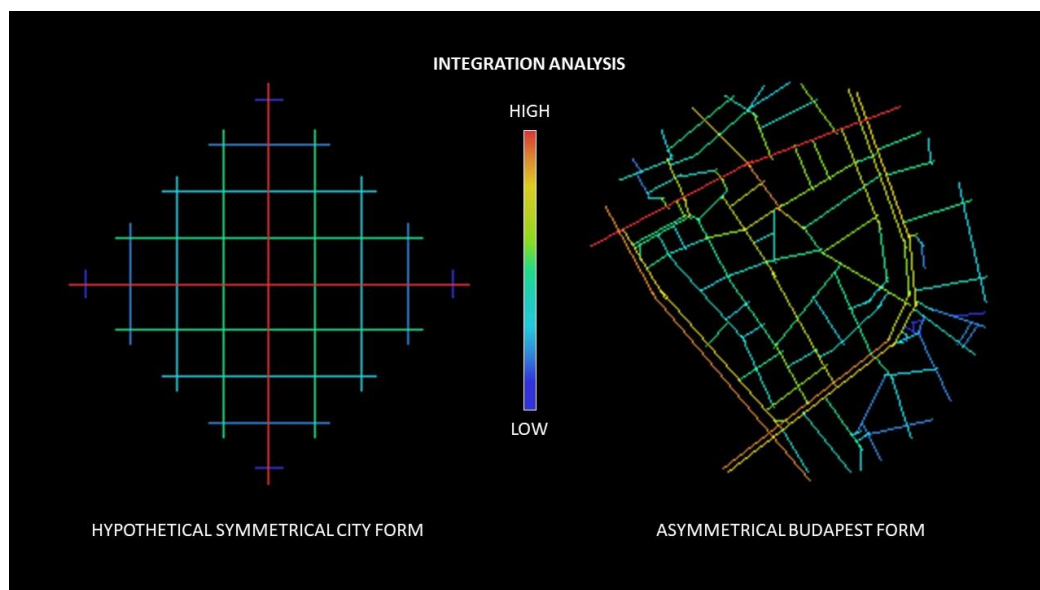


Figure 2. The distribution of integration in a symmetrical pattern and an asymmetrical pattern.

The study case in this research was Pontianak, the capital of the West Kalimantan region in Indonesia. The city is crossed by two rivers: the Kapuas and Landak. There is a tributary right in the heart of the city. The area of the city itself is shaped like a heart (see Figure 3). Because of the rivers, Pontianak currently has three bridges over two different rivers. The Kapuas Bridge connects Area B with Area C, while the Landak Bridges connect Area A with Area B (see Figure 3). The Landak Bridge was a single bridge that was duplicated in 2019 to become the current couple of bridges. Kapuas Bridge will also be duplicated (predicted to be finished in March 2024) to accommodate the growing traffic volume and solve traffic congestion issues.

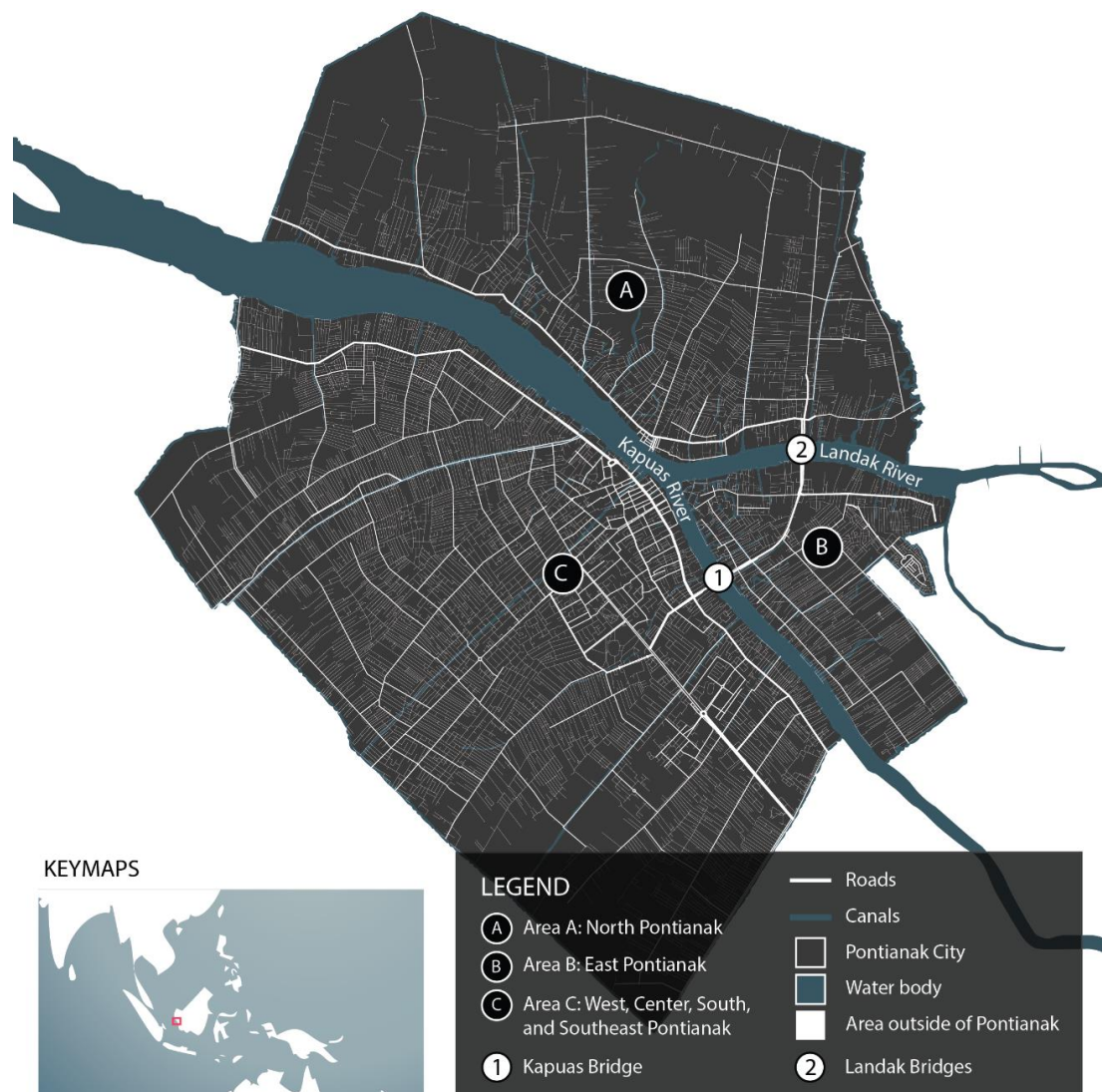


Figure 3. Map of Pontianak as the research area.

Result and Discussion

First Period (before 1771 to 1771)

During the 18th century, the seaside was dangerous and prone to piracy and floods. The place lacked fertile land to grow crops (Heidhues, 2018). People thought the coastal areas of the river were safer and the upstream areas were the safest places. Even so, in the end, humans are still dependent on water. Before the settlement developed, the area was a forest crossed by the Kapuas River, where pirates usually hid (Usman, 2016). The forest was twenty kilometers inland from the sea. Pirates raided the ships of the VOC (Hasanudin & Kristanto, 2012). Sharif Abdurrahman was appointed to guard and drive away the pirates. To be more effective, he built a position in the form of the Jami Mosque and houses (Hasanudin & Kristanto, 2012). This position developed into the palace, which, together with its surroundings, became Pontianak's pioneering settlement.

The first period is the period of the emergence of Pontianak. Naturally, Pontianak already had the complex structure of a natural waterway configuration (Saputra, 2021). The waterways were the very first foundation for water transportation. Because of its complexity, the water transportation network shows an integrated result as a configuration system. It indicates high integration in the tributary (see Figure 4 on the left picture). This explains why the tributary was the pioneering area of Pontianak. Land transportation at this time was only concentrated near the tributary. The network of land roads reflected the location for housing and settlement. The majority of the land was forest (Saputra, 2021). In the beginning, Areas A, B, and C each had a small road segment as the first settlement. All the settlements started near the tributary of the Kapuas River and the Landak River. Settlement in Area A was the Chinese worker settlement. Area B was where the Sultan (Malay King) built his Palace, and the royal followers built their houses. This made Area B the political and economic center of Pontianak. Area C was the least developed area at this time. The land transportation network was tiny, uncomplex, and fragmented. Therefore, it hardly shows a significant integration result (see Figure 4 on the right).

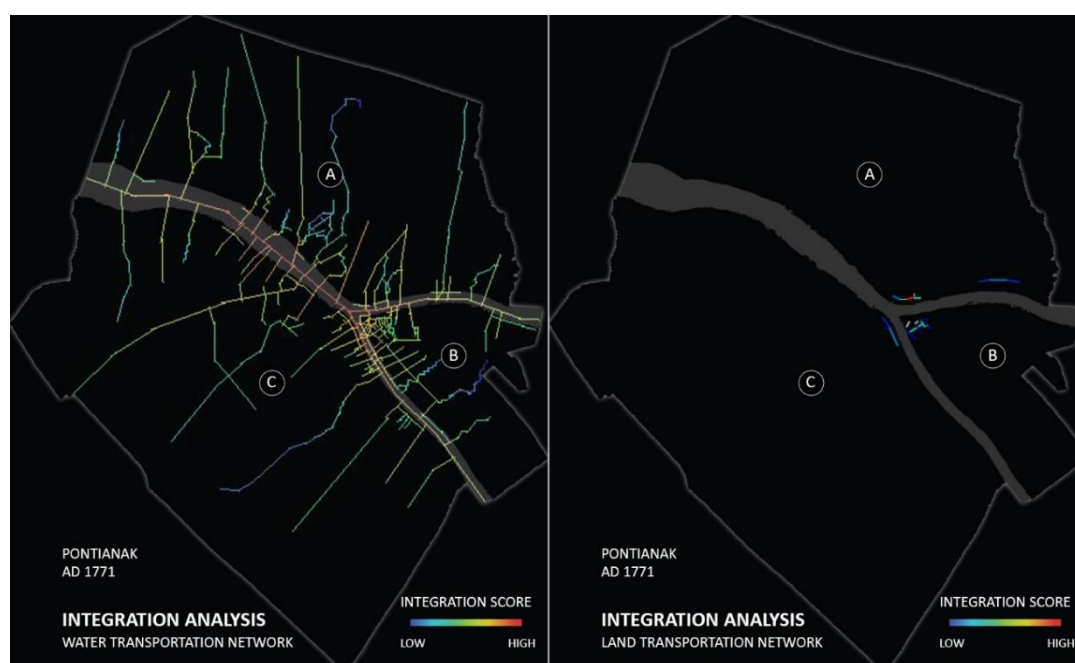


Figure 4. Spatial analysis of Pontianak's water transportation network (on the left) and land transportation network (on the right) in 1771.

Second Period (1771 to 1855)

The second period was when Pontianak experienced a rapid expansion of settlements. The number of royal followers of the Sultan increased. They established their own 'kampung' settlement (Hasanudin & Kristanto, 2012). Pontianak's most significant development event during this period was the arrival of the Dutch East India Company (VOC) (Pontianak City Government, 2019). They negotiated with the Sultan and acquired the land that was known by the Dutch name of 'Duizend Vierkanten Paal' (*Verkendepaal*), now marked by Area C in Figure 5. The arrival of the VOC brought major changes with various development projects such as canals, timber bridges, fortifications, and offices (Usman, 2016). The development of settlements followed water transportation routes such as rivers, natural waterways, and canals (Irfan & Rakhmatulloh, 2020). Due to the density of the settlements on the riverbanks, the settlements began to develop toward land, following the direction of the canals (Nurcahyani et al., 1999).

The canals were important infrastructure at the time. Some canals were normalized natural waterways (Saputra, 2021) but most of them were newly constructed near the settlements. By comparing the water transportation networks from Figure 4 and Figure 5, the most significant expansion in the network of the three areas is indicated by canal projects. The canals served as transport routes and extensions of the river. Another feature of the canals was the ability to reduce the moisture content of the soil and protect the land from wet soil (RCUS, 2015). Because the soil was wet, obtaining suitable land for cultivation was not easy. The canals could also reduce flooding due to the high tidal levels that often occur in Pontianak (Hadrian, 2017). Canals were the orientation of community activities in aspects of agriculture, transportation, economy, and social life. The canals connected the residents with agricultural areas and marketing areas (Sinaga, 2020). The presence of the canals improved the lives of the people of Pontianak. Even so, the canals did not replace the river bank as the city's economic center. The integration analysis shows the same by highlighting the strong integration at the river (Figure 5 on the left). The Kapuas River remained the main generator of the city's growth. In this period, many road segments were also developed, extending the land transportation network. The economic center shifted from Area B to Area C because of the intense development by the VOC.

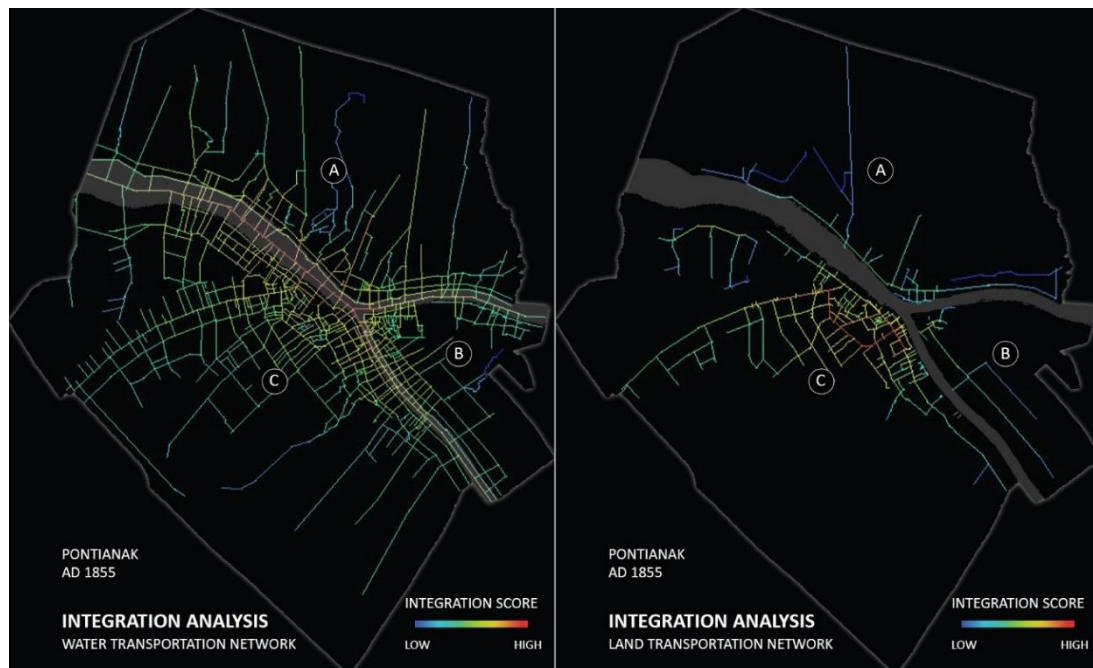


Figure 5. Spatial analysis of Pontianak's water transportation network (on the left) and land transportation network (on the right) in 1855.

This paper argues that the development of the three areas did not make Pontianak a fragmented city as in the concept expressed by Karmila and Magfiroh (2018). According to the findings of Destria and Wibisono (2012), the morphology of Pontianak City developed fragmentedly due to geographical conditions. However, the rivers and canals are not only seen as links between geographical locations. The three areas are connected by the Kapuas River but are at the same time separated by it as a social barrier. In the past, industry and land vehicles were not yet developed (Heidhues, 2018). Water transport was the popular choice for commuting. Therefore, people were easily connected and at the same time divided by the river. This also explains how Pontianak has higher similarity to Java, Singapore, Sumatra, Brunei, and other areas in West Kalimantan compared to Sabah, Sarawak, and East, North, South, and Central Kalimantan.

Third Period (1855 to 1895)

Pontianak kept expanding its territory by attracting more people to settle. People came because Pontianak had a strategic location, providing access to water routes and having a harbor and port (Gunawan et al., 2022). In this period, the Dutch colonial government already controlled Pontianak. The political power of the Sultanate (Malays Kingdom) was weakened. The Dutch colony expanded its territory by imposing new treaties with the Sultanate. The colony established a new market district in Area C by inviting merchants from China to settle and build shops (Bayu & Susanto, 2013). The existence of this market gave rise to the growth of building blocks. The blocks were no longer tied to the topographical conditions and were no longer oriented toward the rivers and canals. This was the beginning of the grid pattern of roads and buildings in Pontianak. The road network could not stand alone. The canal network still accompanied it, because the Kapuas and Landak rivers separated the road network. The development of the canals in Area C spread far inland, connecting to the farming and crop area (see Figure 6 on the left side).

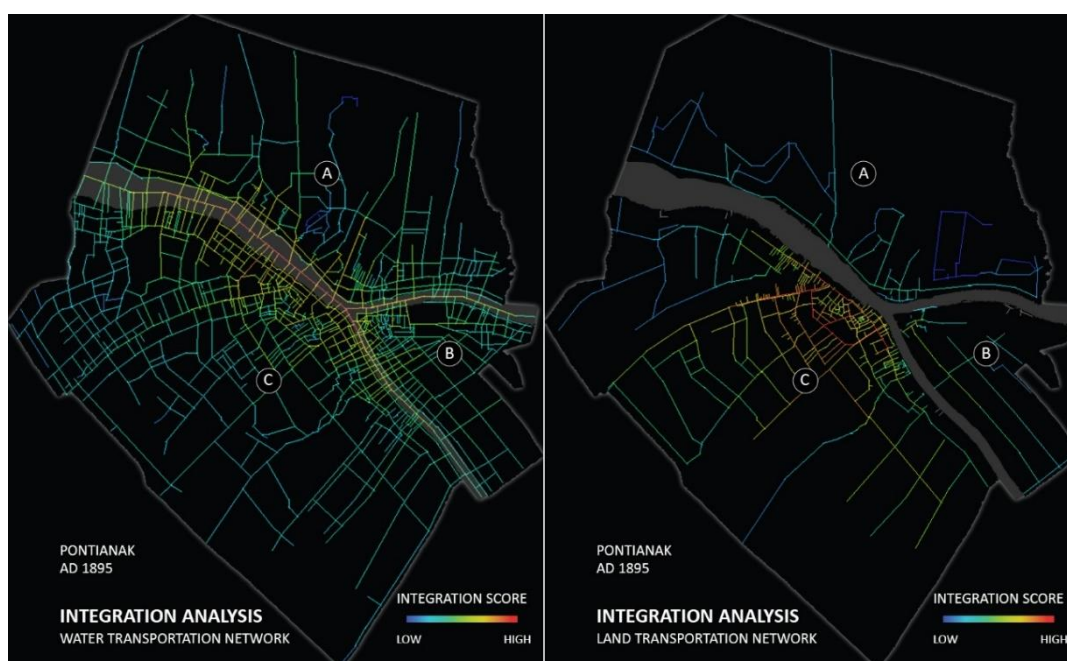


Figure 6. Spatial analysis of Pontianak's water transportation network (on the left) and land transportation network (on the right) in 1895.

The spatial center of Pontianak was still on the banks of the Kapuas River. The water transportation system was still popular and played an active role due to the limitations of land transportation (Bayu & Susanto, 2013). Traffic in the waters of the Kapuas River was increasingly crowded, with goods being transported from Pontianak to cities such as Sintang, Sambas, Singkawang, Sukadana, and small towns along the Kapuas River, as well as to destinations outside the island, such as Java and Singapore (Yusriadi, 2019).

Fourth Period (1895 to 1967)

Pontianak developed into a small city with electric lighting at night (Yusriadi, 2019). More and more infrastructure was established, such as factories, churches, schools, and markets (Hasanudin & Kristanto, 2012). Urbanization occurred during this period (Nurchayani et al., 1999). Many

Malays and Chinese people came to Pontianak with the view that Pontianak was the center of West Kalimantan, a trading city, and a port city that was connected to the outside world. The grid pattern formed by the market spread inland. Urban networks grew dynamically as in other riverside cities (Bayu & Susanto, 2013).

During this period, Pontianak experienced a dynamic change of political power, from the Dutch and the Japanese colonial government to independence. In 1967, Pontianak was already categorized as a regional intermediate-level city (Pontianak City Government, 2019). Pontianak's economy shifted to the industrial sector (Nurhidayati & Arianti, 2021). At this time, flooding was recorded around the Kapuas River due to the high tides at the end of the year (RCUS, 2015). The integration of the water transportation network still marked the Kapuas river and segments near the tributary as the spatial center of the city (see Figure 7 on the left side). Meanwhile, the land transportation network also developed its own central integration in Area C (see Figure 7 on the right side). Among the three areas, only Area C had significant development.

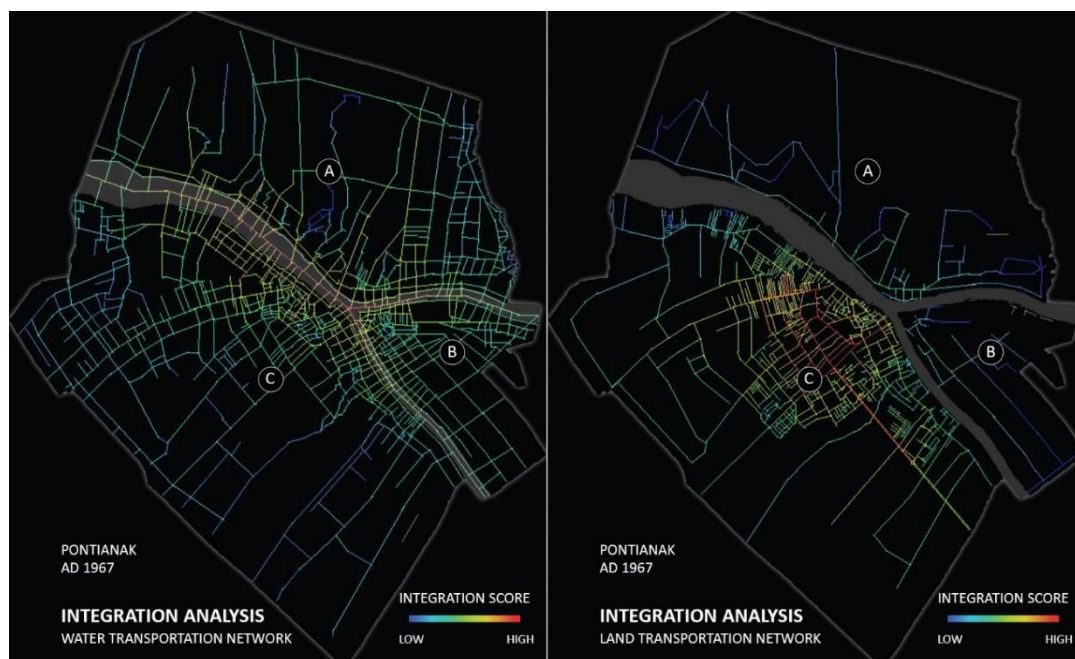


Figure 7. Spatial analysis of Pontianak's water transportation network (on the left) and land transportation network (on the right) in 1967.

Fifth Period (1967 to 1983)

The year 1982 was the time when the Pontianak people began to shift from water transportation to land transportation. The government opened and inaugurated the Kapuas Bridge and the Landak Bridge to reduce the occupancy load of ferry crossing services (Hayat, 2013). These bridges changed the city's structure and shortened the perception of the distance between the three areas. Even so, the activities on the canals and rivers did not die immediately. Goods were still being transported through the canals using boats (Hadrian, 2017) and the canals were still the main transportation option for the population. The city was still characterized by a large number of stilt houses connected by a timber bridge (*gertak*) with a stage height of 2 meters to 3 meters (Nurhidayati & Arianti, 2021). The purpose of such height is for boats to pass through (Purmintasari & Kusnoto, 2018).

The bridges allowed areas A, B, and C to be connected as one big land transportation network (see Figure 8 on the right side). However, some groups of road segments were disconnected from the main network. People were still using water transportation during this period. After the union of the network of the three areas, the integration analysis marked Area C and the bridges as the main route in Pontianak (see Figure 8 on the right side). The market in Area C still held the role of the economic center area, being easily accessible from every corner of Pontianak (Jati et al., 2021). The extension of the bridges improved the development in Area A and Area B, which was previously concentrated in Area C only.

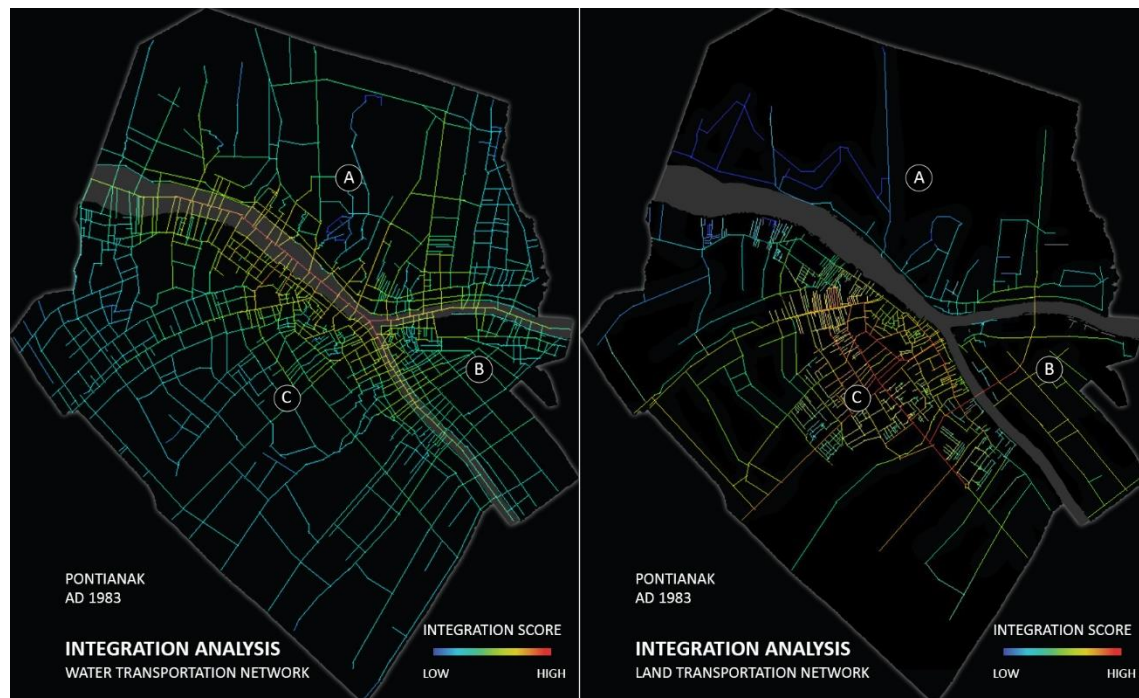


Figure 8. Spatial analysis of Pontianak's water transportation network (on the left) and land transportation network (on the right) in 1983.

Sixth Period (1983 to 2020)

In the next 37 years, from 1983 to 2020, Pontianak developed from forested land into fully occupied land with a complex land transportation network. The degree of urbanization in Pontianak could be categorized as densely populated (Gataric & Đerčan, 2021). People usually commuted from one area to another by the bridges. The integration analysis of the road network shows that traffic was concentrated on the bridges and Area C (see Figure 9 on the right side). The bridges could not accommodate all vehicles due to the rapid increase in land vehicle volume. According to Irfan and Rakhmatulloh (2020), 24% of the traffic commuting from area to area passed through the river using water transportation. The canals were no longer recognized as a transportation route. The water transportation network slowly changed its function to city drainage network. Its size became smaller and some canals were even covered because of road infrastructure development (Bayu & Susanto, 2013). Currently, there are only 42 left that are still identified as canals (Hadrian, 2017). Although the canals are no longer transportation routes, they are an inherent part of society in Pontianak. Currently, there are many village names, district names, and especially street names in Pontianak that refer to canals (*parit* in Indonesian). The roads named after the canals have replaced the canals for a long time.

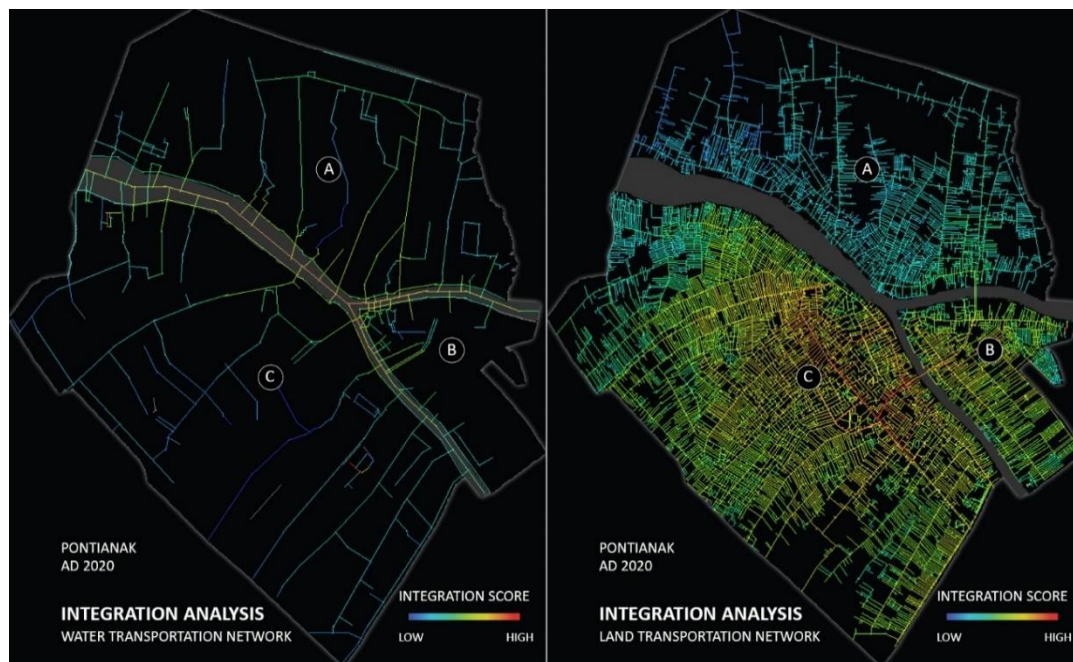


Figure 9. Spatial analysis of Pontianak's water transportation network (on the left) and land transportation network (on the right) in 2020.

By closing the canals, Pontianak began to have several flooding problems, environmental pollution, and traffic congestion. Based on historical records, flood events in Pontianak have occurred since 1993. The city can be inundated with water in one night (RCUS, 2015). In the future, Pontianak will not be able to evade the threat of more extreme floods due to climate change (Nurhidayati et al., 2016), as the topography of Pontianak City is low, at an average of 1.5 meters above sea level. In addition, the type of soil in Pontianak City is 80% wet marshland, which can hardly absorb water anymore (RCUS, 2015). In 2020, flooding occurred in Pontianak with a serious level of impact that caused traffic blocking and difficulties for the land transportation network (Gultom et al., 2020). Based on the data from Gultom et al. (2022b), the flood covered 26.8% of Pontianak's area in 2020.

The problem of environmental pollution increased due to the increasing amount of industrial waste disposal and household waste that polluted the canals (Andriansyah, 2014). Fitri (2013) found a high aluminum content in the Kapuas River with a spread of 500 meters to 2 kilometers from the PDAM waste disposal point. Historically, the people of Pontianak have a social affinity for the rivers and canals, but they have become dirty and toxic trenches. Meanwhile, Sulaiman et al. (2010) claims that inland water transportation is the cleanest. This highlights the potential of the canals for environmentally friendly transportation.

Pontianak is among the top ten cities with the highest traffic congestion in Indonesia. The congestion index of Pontianak is 23% to 24% during peak hours (Oktriasra & Budiati, 2019). The congestion mostly happens in the segments near the bridges from Area A to Area B and from Area B to Area C (see Figure 9 on the right side). The problem of traffic jams may be reduced by revitalizing the canals and rivers in Pontianak as transportation routes.

Water and Land Transportation Trend in Pontianak

Several previous studies have proposed patterns of changes in the morphology of Pontianak. Some revealed dendritic and organic patterns (Hasanudin & Kristanto, 2012), and some proposed that linear patterns turned into grid patterns over time (Nurharahman & Syaodih, 2017). Organic and dendritic are natural development patterns according to existing geographical conditions; this shows how the society depends on the rivers. The orientation of traditional buildings is towards the rivers and the canals. The change from a linear pattern to a grid pattern impacts the development of the market district. Originally, this district was a linear settlement along the river, gradually expanding inland, forming a grid pattern. The linear settlement formed a one-dimensional city that extended along the rivers, but when it became too far from the tributary, the linear settlement stopped extending. The beginning of grid settlement is a sign of land-oriented settlement. This form has a more compact configuration, can accommodate many people, and can easily be extended.

Based on the analysis using space syntax, this paper found changes in road and canal segments or nodes over several periods by node count analysis (see Figure 10). Since the beginning of the establishment of Pontianak City there have been numerous complex branches of the natural waterways, while there were only a few land transportation routes. The canal network developed and expanded rapidly after the arrival of Dutch colonizers from 1771 to 1855. However, from 1855 to 1983, the development of the canal network slowed down and ultimately became stagnant. Nevertheless, the canal network remained more complex than the land transport network until 2020, when this trend was reversed (see Figure 10). The land transportation network increased considerably while the water transportation network decreased drastically because of the construction of the bridges in 1983. The inland water facility and infrastructure in transportation have always been underutilized and undermaintained (Sulaiman et al., 2010). Another reason is that the water transportation business failed to compete with land transportation (Aprilla et al., 2022). How businesses, industries, and the transportation system encourage people to own a car made it seem like there were no water transportation businesses at all. Water vehicles are not easy to own. It is hard to find information on who can manufacture them, where one should go, and whether the business even exists.

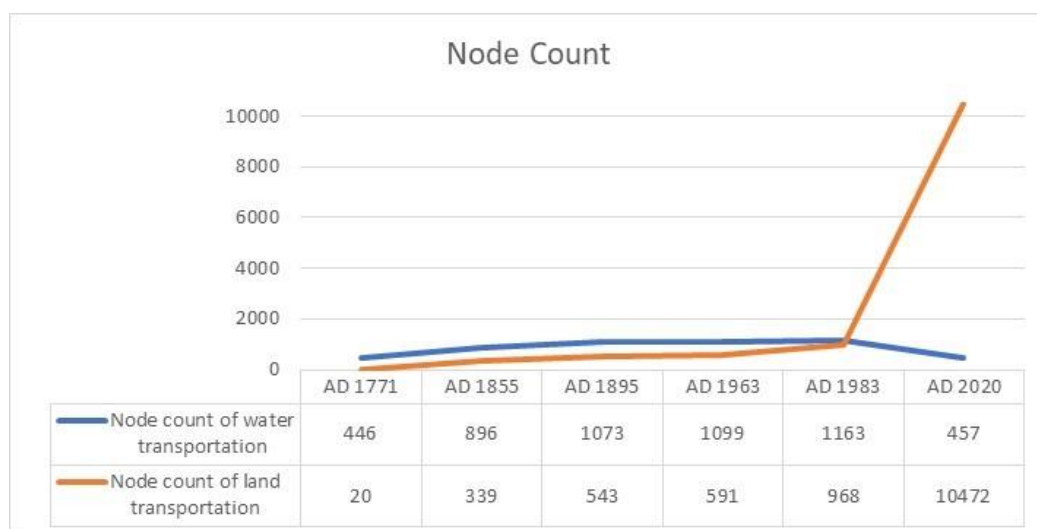


Figure 10. Comparison of node counts (y axis) of water transport networks and land transport networks from 1771 to 2020.

For a mode of transportation, whether over water or land, to be functional and stand-alone, it must have a high continuity rate. The continuity rate is a measurement of how high the main fragment's connectivity with other fragments is. A hundred percent continuity rate means the transportation network is not fragmented – it is fully connected. The continuity rate of water transportation was almost always stable at 100%. In 2020, the continuity rate of water transportation dropped to 95.4% (see Figure 11). This indicates that the canals are no longer passable as transportation routes.

In contrast, the continuity rate of the land transportation network has been consistently increasing. From 1771 to 1855, the continuity rate of the land transportation network improved to 63.42%, i.e., twice the former rate (see Figure 11). Hereafter, the continuity rate slowly improved from around 60% to 70%. The rate exceeded 80% after the construction and inauguration of the Kapuas Bridge and the Landak Bridge. The trend of ground vehicles increased until residents chose land vehicles as the main transportation mode and the continuity rate raised to 100% in 2020. In their research, Gultom et al. (2022a) found a high correlation between the population distribution in Pontianak and the land transportation integration score. This proves the dependence of modern society on land transportation.

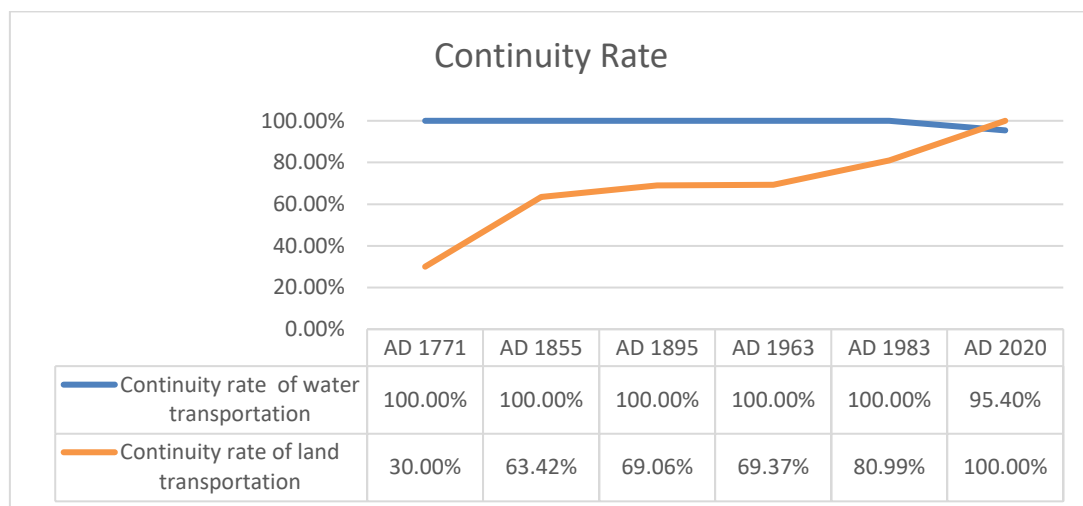


Figure 11. Comparison of continuity rates (y axis) of water transport networks and land transport networks from 1771 to 2020.

Periodically, the integration value of the water transportation network has consistently surpassed that of the land transportation network (see Figure 12). However, based on the trendline, water transportation may have lower integration in the future (see Figure 12). This is made possible by the canals turning into trenches and land vehicles still being the main transportation mode. The comparison proves that integration is not a factor for people shifting away from water transportation.

The comparison also shows that water transportation still has the potential to be an effective transportation mode in Pontianak. The spatial analysis using space syntax shows that Pontianak has a highly integrated canal network, which has the potential to be utilized as transportation system. The government of Pontianak has been working on the congestion issue near the bridges. They plan to duplicate the bridges to accommodate a higher traffic volume. Building a bridge requires a large budget and clearing land for the bridge is difficult since the riverbanks are very crowded. With urbanization and population growth increasing, the traffic volume will soon

outgrow the bridge's capacity. Reactivating water transportation provides another alternative. Water transportation can be the answer to reducing congestion in Pontianak City.

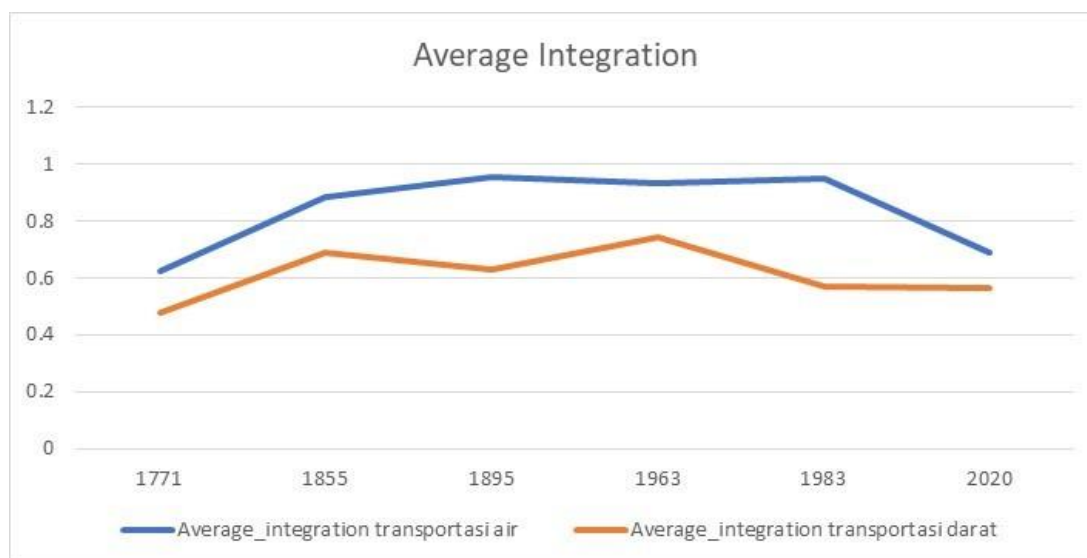


Figure 12. Comparison of the value of the integration (y axis) of water transport networks and land transportation networks from 1771 to 2020 (x axis)

Conclusion

Throughout history, canals were built for transportation and as a behavioral adaptation to living on wet soil terrain in Pontianak. The canals were used to protect against periodic flooding because of high tides, which have worsened from period to period. The canal routes in Pontianak have a good configuration based on our spatial evaluation. They have maintained high integration over each period and always outperformed land transportation. However, due to the inevitable industrial revolution, the main transportation mode has shifted to land transportation, leaving the canals in an extinction process. The construction of bridges in 1983 was the catalyst for the shift towards land transportation by conjoining three land areas in Pontianak. The year 1983 was the marking point for rapid changes.

Currently, Pontianak City is undergoing environmental issues, increasing flood risk, and worsening traffic congestion due to the loss of canals. Revitalizing the canals for water transportation can fix a lot of issues simultaneously. For example, water transportation can be an alternative to reducing land traffic volume and a mitigation option when flooding occurs. The problem is that it requires initial government and manufacturing sector support. Revitalizing the canals can bring a healthy water environment because people will change their perception of the canals from sewage routes to transportation routes. It would also benefit society by creating new job opportunities, opening up new markets, and providing an alternative mode of transportation. Water transportation may make Pontianak more sustainable, more resilient to floods, and create an inclusive multi-use waterbody.

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