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EXPLORING MORPHOLOGICAL DYNAMICS OF PONTIANAK THROUGH QUANTITATIVE STUDY AND CULTURAL INSIGHTS

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This study employs urban mapping techniques to explore the intricate relationship between the built environment and urban processes amidst rapid urbanization. The study area is located in Pontianak city, a city with integrating historical, geographical, and cultural perspectives in Borneo Island, Indonesia. This study unravels Pontianak's urban morphology, aiming to decipher the correlations between accessibility, built form, and cultural identity. Utilizing quantitative methodologies and the Spacematrix method, this research unveils the evolving relationship between accessibility and building density. Analyzing centrality through Space Syntax, it investigates the city's morphological development and cultural identity. The findings highlight Pontianak's adaptability to transportation shifts, emphasizing the impact on its urban evolution. Economic activities strongly shape building density, influencing architectural landscapes across zones. Nuanced correlations between integration, building attributes, and gross floor area underscore historical, cultural, and economic influences. Infrastructure development, notably roads and bridges, significantly enhances connectivity and catalyzes urban growth. This research illuminates the intricate tapestry of Pontianak's urban life, emphasizing its resilience and dynamic evolution amidst changing influences.

***Key words*: centrality, morphology, Pontianak, Space Syntax, waterfront city.**

INTRODUCTION

Numerous historical cities struggle with a critical morphological and typological crisis, a consequence of the pervasive impact of mass production and the standardizing effects of international design (Liang and Cavaglion, 2022). This trend, observed globally, stems from the economic and industrial restructuring and reshaping of cities worldwide (Zhang and Zhang, 2021). Sun and Bao (2021) assert that intricate urban morphology is deeply influenced by political, economic, and social dynamics. In this complex web, advancements in transportation technology augment accessibility, while economic conditions drive the specialization of labor. The interplay of these factors not only forges new urban forms, but also significantly reshapes existing cityscapes and lifestyles (Stojanovski, 2019).

The escalating pace of urbanization in our contemporary world underscores the urgent need to decipher the complex relationship between the built environment and urban processes. This comprehension is pivotal in steering urban development toward more sustainable trajectories (Berghauser Pont *et al.*, 2019). Among the distinctive urban landscapes, waterfront areas stand out, with their unique morphology centered around water bodies (Pekin, 2013). These areas possess a rich history marked by continual transformation owing to their relationship with water and consequential typological shifts (Zhang, 2021). The post-industrial era has introduced a new set of challenges, as many waterfront industrial zones are facing ecological

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and socio-economic crises, triggered by the relocation and transformation of industrial sites, often leading to abandonment (Zhang, 2021).

The core essence of urban morphology revolves around an understanding of geographical features and historical context (Sonne, 2022). An exemplar of such dynamics is Pontianak, a city representing power, and governing the West Kalimantan (West Borneo) Region in Indonesia (Andi *et al.*, 2023). Pontianak's unique geographical footprint is demarcated by the Kapuas River, spanning 150 to 200 meters in width, significantly shaping the city's development (Gunawan *et al.*, 2022). The city's evolution is intricately tied to the Kapuas River and its tributaries, as evidenced by the initial stages of its development. Notably, Pontianak's history is marked by a significant transition from reliance on water-based transportation to favoring land transport, eventually leading to the abandonment of its riverside areas (Gunawan *et al.*, 2022). Prior research by Gunawan *et al.* (2022) has focused on understanding the typology of settlement development in Pontianak's riverside communities, predominantly employing qualitative approaches and investigating the city's urban historical evolution.

Driven by the intricate observations of Pontianak's urban dynamics, this study seeks to delve deeper into the city's morphology using urban mapping techniques, quantitative methodologies, and an in-depth exploration of cultural identity. The primary objective is to unravel the correlations between accessibility, built form, and cultural identity. Employing a quantitative approach is essential to generate reliable and precise datasets, fostering a more profound understanding of the city's morphology and its potential for urban transformation (Erin *et al.*, 2017). The research endeavors to adopt a focused approach, conducting a synchronic study within a specific timeframe in Pontianak. The study's variation will primarily concentrate on exploring three distinct land areas within the city. By juxtaposing these areas shaped by diverse political powers, cultures, and historical influences, the research aims to uncover and elucidate the differences in urban fabric. This comparative analysis intends to contribute significantly to comprehending the multifaceted development of Pontianak.

UNDERSTANDING URBAN MORPHOLOGICAL DYNAMICS

Urban morphology stands as an ever-expanding interdisciplinary realm, drawing global attention from scholars in architecture, geography, and planning (Kristjánsdóttir, 2019; Stojanovski, 2019). At its core, this field encompasses the analysis, interpretation, and evolution of a city's physical form (Sonne, 2022). Employing innovative urban mapping techniques, it unearths intricate connections between how cities are perceived, conceived, and inhabited, shedding light on the intricate tapestry of urban life (Dovey and Ristic, 2017). By integrating historical, geographical, and cultural perspectives, urban morphology unravels the various constraints shaping urban environments and how these influences evolve over time, providing invaluable insights into the city's development (Berghauser Pont and Haupt, 2009).

The practical applications of morphological analysis are wide-ranging and impactful. For instance, within the realm of architectural and urban conservation, it serves as a guiding beacon, informing interventions in historic urban settings and buildings (Daher, 2023). Understanding the nuances of type design and the clustering of urban areas facilitates informed decision-making in urban development, management, and regulation (Potapenko and Moor, 2020). Moreover, this approach serves as a potent tool for prescribing strategies aimed at restoring identity in historical districts threatened by market-driven urban development, ensuring the preservation of cultural heritage (Liang and Cavaglion, 2022). Recognizing the multifaceted significance of urban morphology spans diverse areas, encompassing urban conservation, development, assessment of climate impact, and the restoration of identity in historical areas (Kevin, 2023; Li *et al*., 2021).

Delving into the fundamental elements of urban morphological studies, the examination revolves around two pivotal units: streets and buildings, which serve as essential components of analysis (Berghauser Pont *et al*., 2019). In 2009, Berghauser Pont and Haupt redefined how we measure density by quantifying built form as urban density. This measurement of built and unbuilt space has become an essential urban design tool, helping us understand urban performance. Earlier, in 1984, Hillier and Hanson created Space Syntax using a configurational approach to understand urban performance. While the Spacematrix focuses on the building element, Space Syntax focuses on the street element. These two methods were later adopted and combined by Nes *et al*. (2012) as an effective means to encapsulate urban space within its broader context, aiding in predicting pedestrian movement and spatial understanding of the built form. The same idea of combining Space Syntax and the Spacematrix was also explored by Berghauser Pont *et al*. (2019), in order to understand pedestrian movement. Methodologically, spatial analysis plays a central role, indispensable in calculating street centrality and built density, providing crucial insights into urban configurations. This approach opens up opportunities for further exploration of understanding urban performance and its relationships to political powers, cultures, and historical influences.

METHODS

This research employed a quantitative approach to unveil hidden patterns in the relationship between built forms and accessibility within a city's study area, particularly emerging from its riverside. The method utilized was the Spacematrix method, chosen for its ability to connect density to urban form and other performance metrics (Nes *et al*., 2012). In this context, the additional performance metric examined was accessibility, analyzed through centrality analysis using the Space Syntax method. Space Syntax was chosen due to its robust theoretical foundation and practical applications in analyzing spatial configurations and their impact on social and economic activities within urban environments (Lamprecht, 2022). Furthermore, this research explores cultural identity to gain a deeper understanding of morphological development, akin to the study conducted by Kevin (2023).

The required data for this research involves modeling 2D urban elements and observing building height, and the urban elements considered here are confined to street networks and building blocks, excluding plot elements. These urban elements are pivotal for morphological studies, focusing primarily on shapes and structures that exist physically but might not be directly visible, such as the city's footprint, represented through maps or plans like black plans (illustrating building footprints) (Sonne, 2022). This aligns with Conzen's assertion (2004) regarding the three fundamental elements in urban morphology studies: streets, lots, and buildings, with buildings being depicted only in general footprints without floor plans. Data for modeling was sourced from OpenStreetMap, while the building height observation necessitated field surveys to ascertain the number of stories for each building in the study area.

This study revolves around three key variables: building height (L), building gross floor area (F), and integration (I) of the street network. Building height data was obtained through direct collection, while the other variables required analytical processes. These variables were chosen based on the manner in which morphological structure describes the physical features of cities, encompassing building stories (L), building area (F), and urban elements like buildings, streets, and routes (Stojanovski and Östen, 2018).

The study employed several analyses, including quantification using GIS, centrality analysis, and correlation analysis. In GIS quantification, the building footprints were calculated using QGIS software, because this software offers tools to count the area function ($area) instantly. The software also allowed us to manage and store other data, such as building height and year established. The gross floor area (F) of a building is derived from the product of its footprint (G) and height (L) within the GIS environment. The GIS method helped us to map out and understand how the built form is distributed throughout the study area.

Centrality analysis is analysis from the Space Syntax method. Centrality analysis measures how likely it is for a road to be part of the shortest route between any two roads in a neighborhood. It helps identify the most accessible roads where most activities are concentrated. The analysis is a resulting integration (I) value obtained by utilizing centrality analysis street network data. This analysis allows us to understand the accessibility of the study area.

Drawing inspiration from the common practice of Space Syntax in analyzing built spaces and correlating them with social uses, this study examined the correlation between accessibility and morphology (Sonne, 2022). Once all variables were compiled, correlation analysis was conducted to assess the relationships between building height (L) and integration (I), as well as between the gross floor area (F) and integration (I). Correlation analysis helped us to find the correlation between accessibility and the built form.

STUDY AREA

The study area is situated within Pontianak city, West Kalimantan province, Indonesia. It encompasses a 1 km radius centered around the tributary of the Kapuas river (Figure 1). Many urban phenomena, such as walkability and accessibility, are better understood at the neighborhood scale, which is defined as an area within a 1 km radius, making it a suitable unit for analyzing urban morphology and integration (Spielman and Yoo, 2009). This particular area, believed to be the site of the city's initial settlement, holds historical significance. A previous study conducted by Sun and Bao (2021) similarly focused on an area encompassing cultural and historical significance. This detailed urban morphology study aims to enhance the existing dataset (Li *et al*., 2021). The study area is categorized into three distinct zones: Zone A, Zone B, and Zone C. Zone A marks the genesis of the Chinese settlement, originating from a marketplace that also served as the residential area for the Chinese community. Zone B stands as the pioneer of the entire settlement. It is where the First Sultan initiated the establishment of a palace and mosque. Zone C comprises the Dutch Colony settlement, featuring a fort, administrative office, and residences for Dutch settlers.

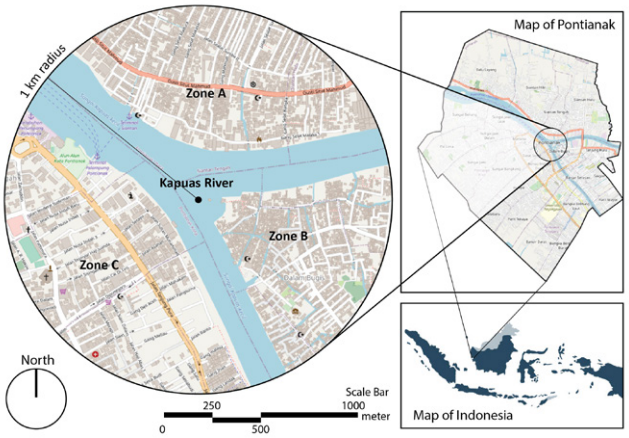

Figure 1. Location of the study area (Source: Authors, 2023)

Founded in 1771 by Sultan Syarif Abdurraham, Pontianak city evolved through a sequential emergence of distinct zones, with Zone B as the initial locus housing the king's palace, succeeded by Zone C and culminating in Zone A (referenced in Figure 2). This chronological development unfolded as the sultan established a regal precinct comprising a palace and mosque in Zone B, around which his followers constructed settlements. Subsequently, the Dutch colonial presence in Zone C led to negotiations for land acquisition, marking the inception of their settlement and the beckoning of Chinese merchants to establish a thriving market in this zone. Eventually, the growing Chinese community's expansion extended to Zone A, creating a central settlement hub. Figure 2 illustrates this expansion from the riverside in Zones A, B, and C, portraying a linear pattern of settlement growth along the riverbanks before radiating inland. The documented timeline draws from maps delineating Pontianak's evolution, spanning from 1771 to 1983, acquired from national archives and

administrative maps, further complemented by online maps from 2023, although newly constructed buildings in 2023 are out of range of the study area.

A comparative exploration of building development and the evolution of road networks reveals intriguing similarities and distinct differences. Initially, both building infrastructure and road networks emerged along the riverside, yet their developmental paths diverged significantly. Building development exhibited a remarkable surge, experiencing exponential growth that surpassed the study area's boundaries, notably peaking between 1855 and 1895. Conversely, the evolution of the road network unfolded at a more gradual pace, reflecting the city's reliance on waterways for transportation during its inception. The city's urban landscape expanded initially along the riverside, with buildings gradually extending inland via canal connections. Roads were a secondary feature, with limited development during this phase (Figure 2). However, a pivotal transformation occurred with the establishment of bridges connecting Zones A, B, and C, marking a significant turning point. This transition spurred substantial growth in the road network from 2003 to 2023, indicating a shift towards road-based transportation infrastructure, as the bridges facilitated enhanced connectivity across the zones (see Figure 2). Pontianak's initial dependence on water-based transportation networks accounts for the slower development of its road network compared to the rapid urbanization and expansion of building infrastructure.

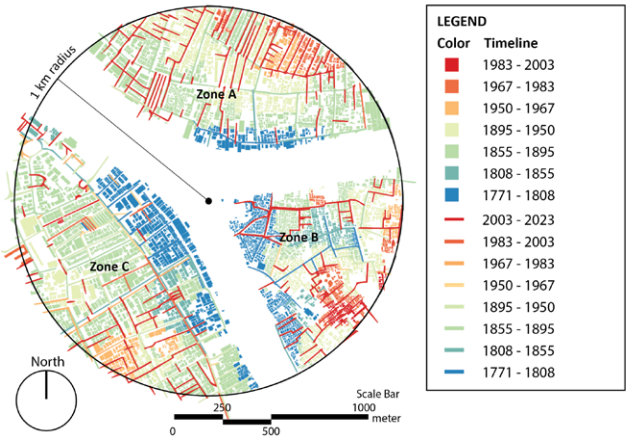

Figure 2. Age of buildings and streets in the study area (Source: Authors, 2023)

RESULTS

Accessibility of Pontianak city

This research employed a larger model of Pontianak city for integration data analysis, deviating from the commonly used segmented model in Space Syntax studies (Atakara and Allahmoradi, 2021). Contrary to the limitations observed in smaller study areas, especially in excluding essential bridge connections, this study adopted a broader perspective, encompassing a radius of 8 km, deliberately incorporating three vital bridges (see the Pontianak city map in Figure 3). These bridges serve as crucial connectors in a city divided by rivers, acting as primary access points between the three zones. Figure 3 demonstrates concentrated high integration values and centrality within Zone C, with Zone B also displaying significant integration due to its bridge connections with Zones A and C. Conversely, Zone A records the lowest integration value, positioned in the outskirts relative to central Zone C. High integration rates signify the potential for increased activity density, such as movement and economic endeavors (Berghauser Pont *et al*., 2019). The integration analysis, as depicted in Figure 3, identifies Zone C as the economic hub, with major roads predominantly concentrated in this area, subsequently extending integration to Zone B and eventually to Zone A.

Narrowing the focus to the study area, a 1 km radius, the integration analysis (depicted in Figure 3) underscores significant integration rates across the three zones. Zone C boasts the highest integration rate on average, followed by Zone B with a moderate rate, and Zone A displaying the lowest integration. Zhang and Zhang (2021) discovered a correlation between accessibility and built form, noting that industries often locate themselves in areas with low integration, often rural or distant from urban centers. In this context, Zone A emerges as the city center, Zone B as the urban area, and Zone C as the suburban region, delineated by varying levels of integration. Pontianak's street network differs notably from cities organized in a grid pattern. Its irregular shape stems from organic growth rather than planned development, as Sonne (2022) notes. Marshall and Gong's (2005) ABCD typology categorizes this irregular street network as Type A, characteristic of old city cores with irregular, meandering streets. Conversely, Type B typifies regular grid-shaped networks. This irregularity impacts connectivity, contributing to Zone B's significantly lower integration. In contrast, Zone C's integration is higher, influenced by the Dutch and European urban planning styles, instilling a grid layout. However, Zone A, despite inheriting the grid pattern from Zone C, records the lowest integration, primarily due to its distance from Zone C, highlighting that street network shape alone may not significantly affect integration levels.

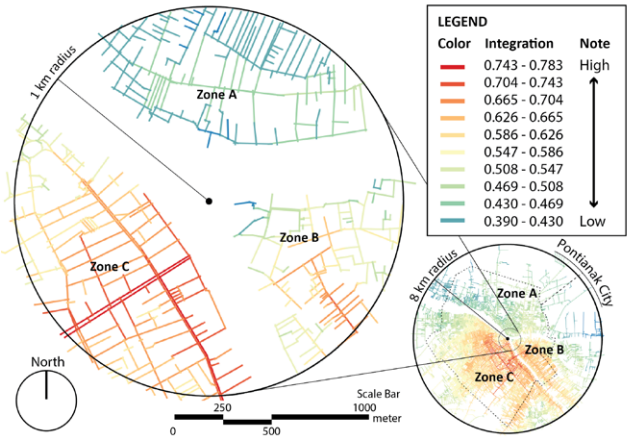

Figure 3. Integration analysis of the study area (Source: Authors, 2023)

Accessibility, crucial in urban planning and design, serves as a fundamental indicator of a city's functionality and socio-economic dynamics. In the context of Pontianak, the investigation extends beyond traditional methodologies, employing a comprehensive approach to evaluating spatial connectivity and its correlation with urban morphology.

This multifaceted analysis, blending spatial connectivity, urban morphology, and historical context, enriches the understanding of Pontianak's development dynamics. It emphasizes the interplay between accessibility, spatial structure, and urban planning influences, offering valuable insights for future urban design interventions and planning strategies.

Built form and building density of Pontianak city

The mapping of buildings in the study area, using stories as the units, revealed distinct patterns through a figure-ground technique, showcasing the extent of built and open areas. Figure 4 illustrates building heights across the zones, notably with Zone A dominated by single-story structures, while a few areas exhibit two-story buildings. Notably, three-story buildings cluster along major roads, the central market in Zone A, and the port area connecting to Zone C, correlating with higher stories accompanying major streets (Figure 4). The maximum height in Zone A peaks at four stories, primarily within factories. In contrast, Zone B predominantly comprises single-story buildings, with very few exceptions like the Keraton Kadariyah (the palace), Masjid Jami (the royal mosque), and a school. Zone C predominantly houses three-story buildings, complemented by some single-story structures within internal blocks accessible via alleys. Moreover, Zone C's major roads feature primarily three-story buildings, with a newly constructed hospital rising to 13 stories, highlighting the zone's diverse range, from three to nine-story buildings. This map effectively delineates density distribution across the study area, emphasizing Zone C's prominence, followed by Zone A and then Zone B.

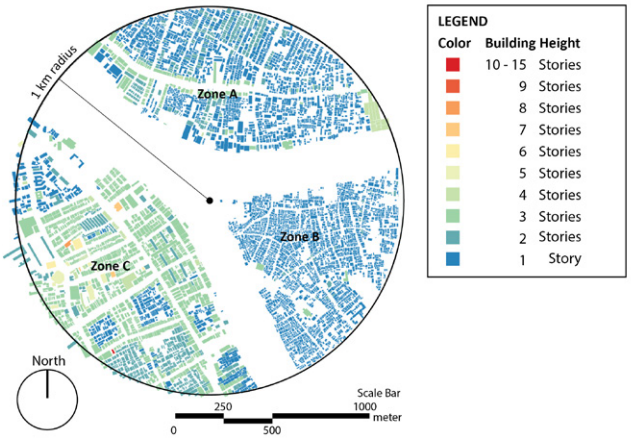

Figure 4. Building height (L) in the study area (Source: Authors, 2023)

A different perspective on built form variation emerges when examining the gross floor area (GFA), calculated by multiplying building footprints by the number of stories. Figure 5 illustrates a GFA range from 7 to 33 square meters as the smallest category and 552 to 18,855 square meters as the largest. Unlike an equal interval classification, the equal count quantile classification method divides data ranges into equal counts, providing a more balanced categorization despite exceptionally high values. Consequently, the GFA map reiterates Zone C's highest building density, trailed by Zone A and then Zone B. In Zone A, the majority falls within the 552 to 18,855 square meter range, while Zone B features predominantly lower mid-range GFAs, characterized by numerous small single-building footprints.

Zone B stands out as a repository for a local architectural marvel known as the "House on stilts," born from Pontianak's flood-prone and swampy terrain (Nurhidayati and Fariz, 2020). This style predominates in the area due to its adaptation to the environment, featuring raised structures supported by stilts, generally limited to one story in height. Additionally, Zones B and C, close to riverbanks, host several traditional Malay dwellings, with approximately 20 and 10 such houses, respectively. These structures, characterized by single-story construction and various sloping roof shapes, typically employ wooden materials (Ciptadi *et al*., 2021). They encapsulate the architectural DNA of the surroundings, exhibiting pavilion-style, single-story structures, which, although material composition may evolve, retain their historical shapes.

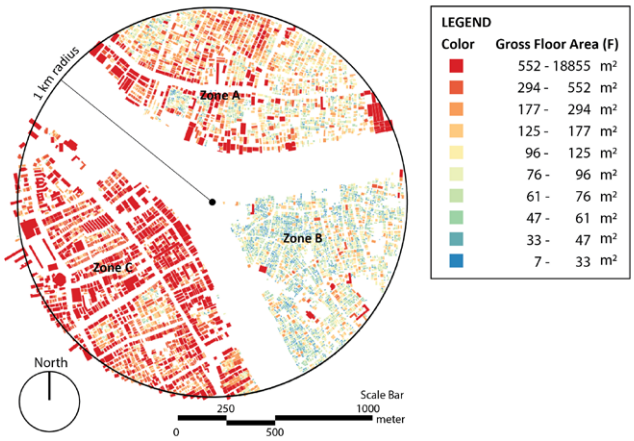

Figure 5. Gross floor area (F) of the study area (Source: Authors, 2023)

Zone A predominantly comprises market areas, reflecting a landscape where residential housing, known as "shop houses," displays a distinct blend of commercial and living spaces (Figure 6). This architectural style, influenced by the predominant Chinese community, primarily engages in mercantile activities. These shop houses commonly feature ground-level stores complemented by upper-story living quarters, aligning with Berghauser Pont's typology of pavilion, street, and cluster types (Berghauser Pont, 2018; Berghauser Pont and Haupt, 2009). In contrast, Zone B encompasses residential neighborhoods characterized by narrow streets and single-story dwellings (Figure 7). These pavilion-style residences, prevalent among the Malay ethnic group, often lack shared walls, fostering a distinct architectural landscape with smaller open spaces. The varied cultural backgrounds between Zone A's predominantly Chinese population and Zone B's mix of Sultanate descendants contribute to marked differences in architectural styles and spatial organization. Zone C emerges as the most developed sector, hosting a network of major roads and functioning as the city's bustling business district since Pontianak's inception (Figure 8). The area's historical significance, underscored by the presence of the Dutch colonial supervisor buildings and fortifications surrounding the Sultanate palace, reflects a power dynamic aimed at securing territorial boundaries against external threats (Andi *et al*., 2023).

Economic activities are integral in shaping building density across the zones. The concentration of economic hubs and market centers drives higher building density, particularly evident in Zone C's commercial and industrial areas. This economic influence directs the spatial distribution and typology of buildings, influencing the heights, functions, and styles seen throughout Pontianak's urban fabric. This interplay between economic activities and built form underscores the pivotal role played by commerce, industry, and societal needs in shaping the physical landscape and architectural characteristics of Pontianak. This diverse urban morphology aligns with the theories of Stojanovski and Östen (2018), elucidating how cultural events and physical spaces intricately shape the unique morphological characteristics of buildings, neighborhoods, and towns. The interplay between cultural influences, historical legacies, and urban planning decisions underscores the distinctive architectural fabric that defines each zone within Pontianak.

Figure 6. A view of the built environment in Zone A
(Source: The photos are retreived from Google Earth Street View, 2023)

Figure 7. A view of the built environment in Zone B
(Source: The photos are retreived from Google Earth Street View, 2023)

Figure 8. A view of the built environment in Zone C
(Source: The photos are retreived from Google Earth Street View, 2023)

Correlation between accessibility and built form

The correlation between integration and building height reflects the relationship between characteristics of the built environment and the street network. Initially, there appears to be a weak overall correlation of 36.2% within the entire study area (Figure 9). Upon closer examination per zone, all zones exhibit a weak correlation between integration and building height. In Zone A, the correlation is 20.5%, while in Zone B, it stands at 18.0% (Figure 9). Notably, Zones A and B display lower correlations, primarily due to the prevalence of single-story buildings. Zone B, in particular, contains a majority of single-story structures, leading to reduced data variance and consequently, and it has the lowest correlation among all zones. Conversely, Zone A showcases a higher correlation because of the frequent occurrence of double-story buildings in the market area situated along the main road. Meanwhile, Zone C demonstrates the highest correlation, owing to the presence of multiple-story structures and greater variability within this zone. Multiple-story buildings are most prevalent in areas with high accessibility, such as main roads. This observation aligns with the higher land value in strategic areas (high integration streets), encouraging maximal land and floor utilization, thus emphasizing the significance of the correlation between building height and integration.

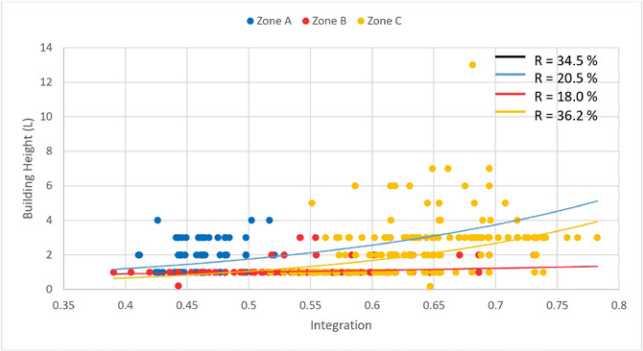

Figure 9. Correlation between integration (x) and building height (y)
(Source: Authors, 2023)

The correlation between integration and gross floor area reflects the relationship between built form and the street network. Initially, it seems that there is a weak overall correlation of 21.6% within the entire system (Figure 10). However, upon closer examination of correlations within specific zones, there is no discernible relationship between these variables. Zone A shows a correlation of 3.2%, Zone B exhibits -0.9%, and Zone C displays -7.6% (Figure 10). None of these values are strong enough to indicate a significant correlation. Additionally, in comparison to the correlation with building height, integration demonstrates a lower correlation with gross floor area (F). Despite the average accessibility in Zone A being lower than Zone B, in term of building density, Zone A has higher value than Zone B. This is because Zone A originally emerged for commercial purposes, while Zone B is for residential purposes, where the king and his loyal followers reside.

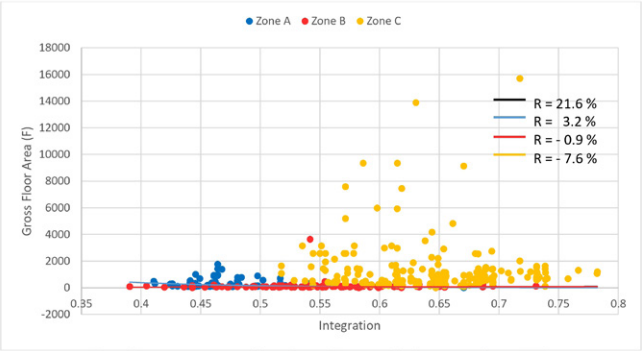

Figure 10. Correlation between integration (x) and gross floor area (y) (Source: Authors, 2023)

DISCUSSION

The evolution of Pontianak city, shaped by the geographical influence of Kapuas River and Landak River, exemplifies a dendritic settlement pattern. This pattern, characterized by branched river streams resembling a tree, and it underscores the organic development of settlements along riverbanks, forming the backbone of the city's transportation network (Nurhidayati, 2015; Sari, 2014; Sirrullah, 2019). The river-centric settlement expansion, observed in Zones A, B, and C, is a hallmark of organic city development, influenced by historical factors and community activities.

The alignment of houses along the river in Pontianak, following dendritic patterns, reflects the reliance on rivers as vital life elements, as elucidated in cultural and geographical studies (Nurhidayati, 2015; Zain and Andi, 2020). Settlement centers, initially developing along the riverbanks, expanded into the mainland, showcasing transportation infrastructure development, such as dirt and bluff roads parallel to the river bank. This dual expansion, both on land and water, contributed to the distinctive layout of Pontianak's settlements, influencing the city's morphological characteristics (Nurhidayati, 2015).

The subsequent chronological evolution of Pontianak saw Zone B as the initial locus, housing the king's palace, followed by Dutch colonial presence in Zone C and the emergence of a thriving Chinese community in Zone A. The construction of bridges connecting these zones marked a pivotal turning point, leading to substantial road network growth from 2003 to 2023. This transition indicates a shift from water-based to road-based transportation, reflecting the city's adaptability to changing needs and influences. The architectural landscape, viewed through building heights and gross floor area, illustrates the interplay between accessibility, economic activities, and cultural identities in shaping each zone. Zones A, B, and C showcase distinct building styles influenced by the Chinese community, Malay ethnicity, and historical legacies. Economic activities, notably in Zone C's commercial and industrial centers, significantly dictate the building density. The correlation analyses between integration, building height, and gross floor area provide nuanced insights into the relationships within Pontianak's zones. Zone-specific correlations emphasize the impact of historical and cultural factors, with higher land values and commercial purposes in Zone A contributing to its unique building density despite lower accessibility.

This study builds on previous research that combines Space Syntax and Spacematrix methods, such as the works of Nes *et al*. (2012) and Berghauser Pont *et al*. (2019). Their studies demonstrate the effectiveness of these methods in urban analysis. Similar studies have shown that Space Syntax can predict pedestrian movement and provide a spatial understanding of urban forms, reinforcing the findings of this research. The work of Stojanovski (2019) and Sonne (2022) highlights the impact of political, economic, and social dynamics on urban morphology, aligning with this study's exploration of these factors in Pontianak. By connecting with these studies, this research validates its methodology and provides a broader context for its findings, contributing to the ongoing discourse on urban morphology and accessibility.

In conclusion, Pontianak's urban development intricately intertwines geographical features, historical legacies, and cultural influences, shaping dendritic settlement patterns and organic city growth. The evolving relationship between accessibility and building density underscores the adaptability of Pontianak to changing transportation modes and economic needs, creating a diverse urban fabric reflective of its rich history and dynamic cultural identity.

CONCLUSION

This research employs mapping techniques and a quantitative approach to studying the morphology of a crucial area in Pontianak city, where its civilization began. The primary objective is to uncover correlations between accessibility, built form, and cultural identity. Pontianak's urban landscape has undergone a remarkable evolution, transitioning from its early beginnings to the multifaceted cityscape it embodies today. Geographical features, notably the Kapuas River and Landak River, played a pivotal role in shaping the city's settlement patterns and transportation networks. These natural elements delineated the spatial organization of Pontianak, guiding the emergence of settlements along their banks and influencing the city's transportation infrastructure. Moreover, the interplay of cultural influences has not only shaped the physical landscape but has also contributed significantly to the socio-cultural identity of each zone within the city.

The evolution of transportation modes, transitioning from water-based to road-based systems, stands as a testament to Pontianak's adaptability and resilience. This shift has significantly impacted the city's development and accessibility, marking crucial turning points in its urban evolution. Furthermore, the correlation between building density and economic activities highlights the strong influence of commerce and industry in shaping the architectural landscape of each zone, emphasizing the economic pulse that beats within the city's heart. An intriguing revelation arises from the nuanced relationships between integration, building attributes, and gross floor area across the different zones. These correlations underscore the complex interplay of historical, cultural, and economic influences on Pontianak's urban morphology. Additionally, the role of infrastructure development, particularly the construction of roads and bridges, has been instrumental in fostering connectivity between zones, catalyzing urban growth, and enhancing accessibility.

The insights gleaned from studying Pontianak's development carry profound implications for urban planning strategies. Understanding the city's historical evolution and its interdependent factors can inform future urban planning initiatives, guiding efforts toward sustainable growth, infrastructure development, and the preservation of cultural heritage. Pontianak stands as a testament to the intricate interconnections between history, culture, economics, and geography in shaping urban landscapes, offering valuable lessons for urban planners and policymakers striving to create vibrant and sustainable cities.

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REFERENCES

Andi, U. F., Irwin, I., Zain, Z., Pebriano, V., Andi, A. (2023). Power over architecture: A case study on Malay Sultanate Palaces in West Kalimantan during colonial period (1800-1949 AD), *International Journal of Environment, Architecture, and Societies*, Vol. 3, No. 2, pp. 96–105. https://doi.org/10.26418/ijeas.2023.3.02.96-105

Atakara, C., Allahmoradi, M. (2021). Investigating the urban spatial growth by using space syntax and GIS—A case study of Famagusta city, *ISPRS International Journal of Geo-Information*, Vol. 10, No. 10. https://doi.org/10.3390/ijgi10100638

Berghauser Pont, M. (2018). An analytical approach to urban form. In V. Oliveira (Ed.), *Teaching Urban Morphology*. Springer International Publishing, pp. 101-119. https://doi.org/10.1007/978-3-319-76126-8_7

Berghauser Pont, M., Haupt, P. (2009). *Space, Density and Urban Form*. Delft: Delft University of Technology.

Berghauser Pont, M., Stavroulaki, G., Marcus, L. (2019). Development of urban types based on network centrality, built density and their impact on pedestrian movement, *Environment and Planning B: Urban Analytics and City Science*, Vol. 46, No. 8, pp. 1549–1564. https://doi.org/10.1177/2399808319852632

Ciptadi, W., Hamzah, E. R., Binta, I. (2021). Kearifan lokal pada proses pembangunan sistem fisik (physical system) rumah tinggal Tradisional Melayu tipe potong limas di Kota Pontianak, Kalimantan Barat, *Vokasi: Jurnal Publikasi Ilmiah*, Vol. 16, No. 2, pp. 57–67. https://doi.org/10.31573/vokasi.v16i2.333

Conzen, M. R. G. (2004). *Thinking about Urban Form: Papers on Urban Morphology, 1932-1998*. Oxford; New York: Peter Lang.

Daher, R. F. (2023). Effect of typo-morphological analysis and place understanding on the nature of intervention within historic settings: The case of Amman, Jordan, *Archnet-IJAR*, Vol. 18, No. 1, pp. 1-20. https://doi.org/10.1108/ARCH-05-2022-0114

Dovey, K., Ristic, M. (2017). Mapping urban assemblages: The production of spatial knowledge, *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, Vol. 10, No. 1, pp. 15–28. https://doi.org/10.1080/17549175.2015.1112298

Erin, I., Araldi, A., Fusco, G., Cubukcu, E. (2017). Quantitative Methods of Urban Morphology in Urban Design and Environmental Psychology, *Proceedings 24th ISUF 2017 - City and Territory in the Globalization Age. 24th ISUF 2017 - City and Territory in the Globalization Age*. https://doi.org/10.4995/ISUF2017.2017.5732

Gunawan, I., Soemardiono, B., Septanti, D. (2022). Typology of settlement development in riverbanks in Pontianak, *International Journal of Environment, Architecture, and Societies*, Vol. 2, No. 2, pp. 73–84. https://doi.org/10.26418/ijeas.2022.2.02.73-84

Kevin, A. (2023). *Reviving Local Traditional Culture through Typo-Morphological Approaches*. Cambridge: Department of Architecture, University of Cambridge. https://doi.org/10.31219/osf.io/q25ew

Kristjánsdóttir, S. (2019). Roots of urban morphology, *ICONARP International Journal of Architecture and Planning*, Vol. 7, Special Issue, pp. 15–36. https://doi.org/10.15320/ICONARP.2019.79

Lamprecht, M. (2022). A Review of Potentials in the Polish Context, *Miscellanea Geographica*, Vol. 26, No. 1, pp. 5–14. https://doi.org/10.2478/mgrsd-2020-0072

Li, H., Liu, Y., Zhang, H., Xue, B., Li, W. (2021). Urban morphology in China: Dataset development and spatial pattern characterization, *Sustainable Cities and Society*, Vol. 71. https://doi.org/10.1016/j.scs.2021.102981

Liang, X., Cavaglion, G. (2022). A cultural perspective on the typo-morphological approach: A planning proposal for Hehua Tang, China, *Cities as Assemblages*, Vol. 3, No. 1, pp. 91–100. https://doi.org/10.36158/97888929535749

Marshall, S., Gong, Y. (2005). *Urban pattern specification*. London: Institute of Community Studies.

Nes, A., Berghauser Pont, M., Mashhoodi, B. (2012). Combination of Space syntax with spacematrix and the mixed use index: The Rotterdam South test case, PAPER REF#8003, *Proceedings: Eighth International Space Syntax Symposium*. Santiago: PUC, pp. 1-28.

Nurhidayati, E. (2015). Formasi dan Karakteristik Pola Permukiman di Kawasan Waterfront City Pontianak, *Seminar Nasional "Menuju Arsitektur Dan Ruang Perkotaan Yang Ber-Kearifan Lokal" PDTAP*, pp. 134–146.

Nurhidayati, E., Fariz, T. R. (2020). Kebertahanan pemukiman rumah panggung di tepian Sungai Kapuas Pontianak, *Mintakat: Jurnal Arsitektur*, Vol. 21, No. 2. https://doi.org/10.26905/mj.v21i2.4090

Pekin, U. (2013). Urban Waterfront Regenerations. In M. Özyavuz (Ed.), *Advances in Landscape Architecture*. IntechOpen. https://doi.org/10.5772/55759

Potapenko, A., Moor, V. (2020). Vladivostok City Morphology: Space Matrix as a Tool for the Urban form Analysis, *IOP Conf. Ser.: Earth Environ. Sci.* 459 052039. https://doi.org/10.1088/1755-1315/459/5/052039

Sari, I. K. (2014). Perubahan karakter arsitektur permukiman Kampung Beting Kota Pontianak Kalimantan Barat, *Langkau Betang: Jurnal Arsitektur*, Vol. 1, No. 1, pp. 62–75. https://doi.org/10.26418/lantang.v1i1.18809

Sirrullah, S. S. (2019). *Sejarah Kesultanan Kadriah Pontianak 1778 M - 2017 M*. (Bachelor's Thesis, Universitas Islam Negeri Sunan Ampel, Surabaya, Indonesia). http://digilib.uinsa.ac.id/29237/ [Accessed: 24 Nov 2023].

Sonne, W. (2022). Urban Typology, Morphology, Iconography. In J. M. Gurr, R. Parr, D. Hardt (Eds.), *Metropolitan Research: Methods and Approaches* (1st Ed.). Bielefeld: transcript Verlag,

pp. 17-35. https://doi.org/10.1515/9783839463109-002 https://doi.org/10.14361/9783839463109-002

Spielman, S. E., Yoo, E. (2009). The Spatial Dimensions of Neighborhood Effects, *Social Science & Medicine*, Vol. 68, No. 6, pp. 1098–1105. https://doi.org/10.1016/j.socscimed.2008.12.048

Stojanovski, T. (2019). Swedish typo-morphology – Morphological conceptualizations and implication for urban design, *ICONARP International Journal of Architecture and Planning*, Vol. 7, pp. 135–157. https://doi.org/10.15320/ICONARP.2019.81

Stojanovski, T., Östen, A. (2018). Typo-morphology and environmental perception of urban space, *Proceedings of the XXV ISUF International Conference*, pp. 822–834. https://elib.sfu-kras.ru/handle/2311/111758

Sun, Y., Bao, L. (2021). Transitional urban morphology and housing typology in a traditional settlement of 20th century, Nanjing, *ISUF 2020 Virtual Conference Proceedings*. https://doi.org/10.26051/0D-F6J8-8FYF

Zain, Z., Andi, U. F. (2020). The intangible characteristics of the two indigenous traditional dwellings in West Kalimantan, *A|Z ITU Journal of the Faculty of Architecture*, Vol. 17, No. 1, pp. 25–36. https://doi.org/10.5505/itujfa.2019.97720

Zhang, G. (2021). Comparison study of typology transformation in waterfront industrial district: Arsenal in Venice and Yangpu riverside in Shanghai, *ISUF 2020 Virtual Conference Proceedings*. https://doi.org/10.26051/0D-V5R2-SHNM

Zhang, G., Zhang, S. (2021). Typo-morphology transformation of industrial archeology in Treviso: Fornace Guerra Gregorj as an example, *ISUF 2020 Virtual Conference Proceedings*. https://doi.org/10.26051/0D-7YTW-0A9M

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