

RESEARCH ARTICLE

Evaluation Study Of Walkability Index In Central Business District (CBD) Area, Pekanbaru City

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Abstract

Walkable cities emphasize cities with high walkability values, where walkability can be defined as the degree to which the environment can be pedestrian friendly. Walkable city is considered to be able to increase people's desire to walk so that it can make the environment more humanistic and can also help realize one of the objectives of sustainable transportation. The value of walkability can be viewed from the perspective of the urban form (macro level) of an area. The Central Business District (CBD) Pekanbaru City walkability index assessment uses the WAI IPEN Project model that measures the form of the Urban Form. The walkability assessment process in the Pekanbaru Kota Sub-District Area (CBD) divides the study area into 6 grids. The analysis shows that there are 4 grids that have a negative walkability value. In the analysis of the walkability value pattern it can be seen that the area dominated by office activities has a lower walkability value compared to the area that has mixed land use.

Keywords: walkable city, CBD, WAI IPEN Project

1. Introduction

A walkable city is a city planning concept supported by transportation planning that enables its citizens to walk in their daily activities. The concept of walkable city emphasizes cities that have high walkability where walkability is defined as the level of an area within walking distance of a building to its destination (Pivo and Fisher, 2011). Walkability can be viewed from various perspectives such as in terms of urban design, transportation and urban form which are viewed from a more macro and close to the spatial layout. Based on a survey conducted by Urban Mobility for Indonesia, 12% of people choose to walk rather than using bicycles and traditional environmental transport such as pedicabs or delmans as non-motorized transportation when traveling (Patsinai, 2013). Related to this, the concept of walkability was introduced as one indicator of sustainable city development. By walking, traffic congestion and air pollution generated by motor vehicles can be reduced (Forsyth, 2015; Forsyth and Southworth, 2008).

More and more studies, especially from the United States (US) and Australia, show that neighbourhoods walkability is an important correlate of physical activities such as walking behaviour, this suggests that creating a more walkable community may be a powerful and cost-effective tool for promoting physical activity to population (Ribeiro and Hoffmann, 2018). Previous studies have identified several correlations between neighborhoods

development and physical activity, including the walkability of the residential neighborhoods. Walk ability reflects the comfort of the communities built for walking; the level of support based on three main component indexes; road connectivity, residential density, and mixed diversity of land uses. An environment characterized by many interconnected roads, high residential density and different diverse area uses is considered very easy to pass (Van Holle et al., 2014). Geographic Information Systems (GIS) can be used to measure artificial neighborhood features that can affect physical activity objectively. GIS data has the potential to be used to build measures of neighborhoods attributes and to develop an index of walking ability for cities, regions, or local communities (Leslie et al., 2007).

The concept of Walkable City emphasizes a city with a high value of walkability, walkability can be defined as the degree to which the environment can be pedestrian-friendly. The concept of Walkable City is considered to be able to increase people's desire to walk so that it can make the environment more humanistic and can also help realize one of the objectives of sustainable transportation. The value of walkability can be viewed from the perspective of the urban form of an area.

Pekanbaru City is currently very intense in building pedestrian paths on several roads, one of them is Jalan Jenderal Sudirman in Pekanbaru Kota Sub-District. This sub-district is included in WP I as the primary center of Pekanbaru City with its main function being

the service and office trade area. As the primary center of the city, the Pekanbaru Kota sub-District is a strategic area that has a large economic, social and environmental influence in the local and regional scope. This condition certainly makes the Pekanbaru Kota sub-District as the Central Business District (CBD) of Pekanbaru City.

From the description of the condition of the Central Business District (CBD) of the City of Pekanbaru above it can be concluded that the condition of the pedestrian lane in the District of Pekanbaru Kota has been very good in terms of physical, but has not had a significant impact in increasing the number of pedestrians engaged in the City CBD Pekanbaru.

Based on the above issues, this study aims to assess the Pekanbaru Kota sub-District as the Central Business District (CBD) of Pekanbaru City based on the IPEN Project Walkability Index as a measure of the level of environmental friendliness of the Pekanbaru City CBD towards pedestrians.

2. Literature Review

(Moura et al., 2017) defines walkability as a measure of the extent to which an urban environment can be friendly to pedestrians. By measuring it, planning experts might be able to improve the quality of the pedestrian environment, supporting strategies and interventions related to walking that are more objective, effective, and comprehensive. There are many different ways to consider "walkability." For example, in many developed countries, walkability discussions focus on encouraging modal shifts from motorized vehicles to non-motorized vehicles for short trips or promoting walking as a healthy recreational activity. In developing cities, walking is often considered in terms of providing mobility for the most impoverished population. Some urban planners tend to think of walkability in terms of urban spatial planning, preferring to use mixed zones rather than separate land uses (Krambeck and Shah, 2006). (Leslie et al., 2007) define walkability as "the extent to which the characteristics of the built environment and land use are conducive for residents to walk either for recreation, sports or recreation, to access services, or to travel to work.

Walkability is a composite measure of four neighborhood attributes measured objectively: occupancy density, road connectivity, mixed land use, and net retail area ratio. Several studies have found this environmental attribute to be consistently associated with walking behavior (Owen et al., 2004; Saelens et al., 2003). The walkability index was developed in the 2000s. The walkability index combines the main built environment features that encourage walking behavior such as road network connectivity, mixed land use, and residential density (Ribeiro and Hoffmann, 2018). (Jun and Hur, 2015) found some literature showing that physical environmental factors can be a tool to improve the social environment. These physical environment characteristics encourage more pedestrians to engage in activities on the road, present more opportunities

for informal contact, and promote social cohesion as naturally. (Lund, 2002) found that residents in traditional environments have a greater sense of community and are more likely to walk in their environment than people in modern suburban environments. (Owens, 1993) argues that inadequate population density and mix-use settings allow people to walk more.

Some researchers also investigated the factors that classify each block group having "high" or "low" walk ability. The measured walk ability components include net occupancy density, junction density, land use mix, and retail floor area ratio (Carlson et al., 2015; Frank et al., 2010; Saelens et al., 2012). Many studies have identified differences in the types of walking and how the built neighborhood influences them: walking for transportation is related to neighborhood design, whereas recreational walking has not been proven to be influenced by neighborhood design (Rodríguez et al., 2006).

3. Methodology

The development of the concept of walkability based on the IPEN Project in this study uses a combination of methods or mixed methods, where quantitative methods are carried out in the systematic calculation of urban form conditions, while qualitative methods are used in assessing the walkability of an area subjectively. This method is considered to be able to explain and describe the process and results to be achieved.

From this conceptual framework, methodological indicators for evaluating walkability through GIS-based and examining the road network are presented. It was applied to an area in Lisbon, Portugal, to assess the ease or difficulty that can be faced by various types of pedestrians in their walking activities and, potentially get information for intervention and improvement (Moura et al., 2017).

3.1. Walkability Index

The walkability index is obtained by adding up a partial index consisting of connectivity index, entropy index, FAR index, and household density index. All partial indices are calculated for each sub-district within an urban area to measure the comfort level of an urban environment in facilitating pedestrians. The walkability index uses the following formula (Dobesova and Krivk, 2012):

$$WAI=(2*con)+ent+far+hdens$$

Explanation :

WAI = Walkability Index
con = Connectivity Index
ent = Entropy Index
far = Floor Area Ratio (FAR) Index
hdens = Households Density Index

The value generated from the walkability index must indicate the physical activity of people in a certain area. An index value higher than the walkability index indicates that there is a greater likelihood that people will do more physical activity.

3.2. Connectivity Index

The first partial index which is the input for the resulting walkability index is the connectivity index. Connectivity is also called intersection density, which is calculated from the number of intersections per square kilometer of urban units. Digital data input is a line of road geometry in a city. Road crossing data obtained from aerial photographs that are still relevant to use in the past 5 years or satellite imagery in the latest year will be made into a road network map. While the highway is excluded from the input data because it is not suitable to be passed. In addition, the area of water bodies and rivers is reduced from the area of the city unit.

Calculating the index, each intersection is given a valence value. This value represents the number of roads that meet at a certain intersection. The "T" shaped crossroad has a valence value of three, an "X" shaped four. Then, any crossroads that are too close, which means closer than 15 m, are combined and treated as one crossing. This intersection is then given a higher valence. Knowing the connectivity index is calculated using a formula derived from (Dobesova and Krivk, 2012).

$$con = \frac{\Sigma Crossroads}{1 km^2}$$

Explanation :

con = Connectivity Index

3.3. Entropy Index

The entropy index shows how homogeneous or heterogeneous usage in a certain area. The higher the diversity of land uses, the higher the entropy index. The key to calculating the entropy index is high-quality land use polygon layers. Types of land use in the entropy index assessment are divided into eight basic categories.

Table 1. Basic Categories of Land Use Types	
Category Name	Mark
Living	L
Commercial	C
Services	S
Industrial	I
Institutional	T
Recreational	R
Other	O
Water	W

$$H(S) = \frac{-\sum_{t=1}^k (P_t) \cdot (\ln P_t)}{\ln k}$$

Explanation :

H(S) = Entropy Index

Pi = Area ratio for each land use category to the total area of all categories

k = Number of existing land use categories

3.4. FAR (Floor Area Ratio) Index

The FAR index represents the ratio of shop building area to all areas of land use categories that are

commercially labeled. It is estimated that a high index indicates that the place has a significant percentage of smaller retail stores. Such an area would certainly be more interesting to walk than others. When the FAR index has a low value, there may be more shops and shopping centers with large parking lots. Therefore, it's easier to use the car to shop. To calculate Floor Area Ratio (FAR) using a formula derived (Dobesova and Krivk, 2012).

$$FAR = \frac{\Sigma The total floor area of retail stores}{\Sigma The total area of commercial area}$$

3.5. Households Density Index

In calculating the density of settlements, it is necessary to have information about each unit of the number of households in the city. The number of households is divided by the area designated for the urban settlement function. The data needed in the calculation of the household density index is the total area of the type of land use that is marked with L (Living) and the total floor area of a house in an urban area. Index values reflect life forms in urban areas. High values represent the high density of households. To calculate the Settlement Population Index using the sourced formula (Dobesova and Krivk, 2012):

$$hden = \frac{\Sigma Floor area of the house building}{\Sigma Size of residential area}$$

Explanation :

L (meter) : The total area of residential floor on one grid in meters

L (acre) : The total area of residential floor on one grid in an acre

LA divider (constant) : The number of residential building blocks that exist on one grid

Hdens : H-dens Index Value (not standardized)

Average : The average value of the H-dens Index (required in calculating the standard value of the H-dens Index)

4. Data And Variables

This study uses various data sources that can be divided into two types, namely primary data and secondary data that are qualitative and quantitative. There are several methods used in primary data collection, including the process of determining the characteristics of the problem, the data used is image data / aerial photographs taken using drones and after that the process of observing the interpretation of the results of the image / aerial photograph by correcting the results of interpretation in the field directly. Other object data collection is done by observing and documenting pedestrian facilities, crossing roads, homogeneity of land use, activity functions on the ground floor and upper floors of each building.

Table 2. Data and Variable

Variable	Data	
Connectivity	5.	Number of Intersections
	6.	Types of land use
Entropy	7.	Area of each land use
	8.	The lower zone land use per parcel
	9.	Land use upper zone per parcel
	10.	Characteristics of activities
	11.	Map of area blocks
FAR (Floor Area Ratio)	12.	Population density
	13.	Shop building area
	14.	Extensive trading area
	15.	Building height (number of floors)
Households Density	16.	Building area of the house
	17.	Extensive residential area

Table 3. Con Value (Z-Value)

Grid	Junction Count	Crossing Count	Junction Constant	Crossing Constant	Junction Score	Crossing Score	Crossin & Junction Score	Con (Z Value)
1	30	13	3	4	90	52	142	-2,041483
2	47	14	3	4	141	56	197	6,941042
3	60	3	3	4	180	12	192	6,124449
4	35	6	3	4	105	24	129	-4,164625
5	36	10	3	4	108	40	148	-1,061571
6	37	2	3	4	111	8	119	-5,797812
Total							927	
Average Score							155	
Standard Deviation							6,123	

5. Discussion

In theory, walkability has many concepts. In general, there are three approaches to walkability, namely from the transportation side, the urban design side and the urban form side. Improved quality of walkability from all three sides of this approach greatly affects the walking behavior of urban communities. In this study assessing walkability from the urban form side. The urban form itself consists of variable housing density, diversity, land use, and environmental road patterns. The walkability approach is taken looks at the macro scale compared to the other two approaches. This approach is considered the most suitable way to get into spatial planning because it emphasizes land use that affects people's walking desires. From the urban form approach, the concept of walkability used in this study is the IPEN Project concept. This concept has four parameters in calculating the walkability index (value of walkability), namely the diversity of proportional area activities (entropy index), regional connectivity (connectivity index), the ratio of the floor area of commercial activities (FAR index), and occupancy density (H-dens). These four parameters are derived from three urban form variables. An area has a high walkability value when all four parameters are positive/high.

5.1. Connectivity Index Analysis

The connectivity index shows the number of intersections in the research area. The number of intersections is believed to make the area more

connected. The IPEN Project states that the intersection in environmental blocks will make it easier for pedestrians to reach their destination because the intersection provides a more direct path to the destination (not circling).

Grids that have good accessibility are grid 2 (Area around Ahmad Yani Street with Jalan Hidayat Street), grid 5 (Area around An-Nur Great Mosque), and grid 6 (the area around Jalan Diponegoro). In addition, there is also a positive value grid but because the result is close to 0 like grid 1 which can be said to be a normal accessibility condition. While grid 2 and negative value and can be interpreted that the number of intersections is small so that accessibility is low (Table 3) (Fig. 1).

5.2. Entropy Index Analysis

Entropy Index is a measure of the level of diversity of land use/function in the study area. The more diverse and equitable the function/land use of an area, the higher the level of walkability. Areas that have high diversity are believed to have many destinations that can be chosen by residents. Pedestrians will be more interested in walking in an environment that has many variantsof activity than those who have uniform uses because there is a lot they can do and further increase their reasons for walking.

From the calculation results (Table 4), it can be seen that the grid that has a high Entropy Index value is on grid 6, grid 5, and grid 4 (sorted by rank). Meanwhile, the grid that has a low Entropy Index value is grid 1, grid 3, and grid 2. If further observed, the grid that has a high Entropy Index.

Table 4. H (S) Region Grid Value

Grid	H(S)	Z-Score H(S)
1	0,374	-1,407
2	0,513	-0,643
3	0,497	-0,731
4	0,76	0,714
5	0,779	0,819
6	0,856	1,242
Average	0.63	
Standard Deviation	0.182	

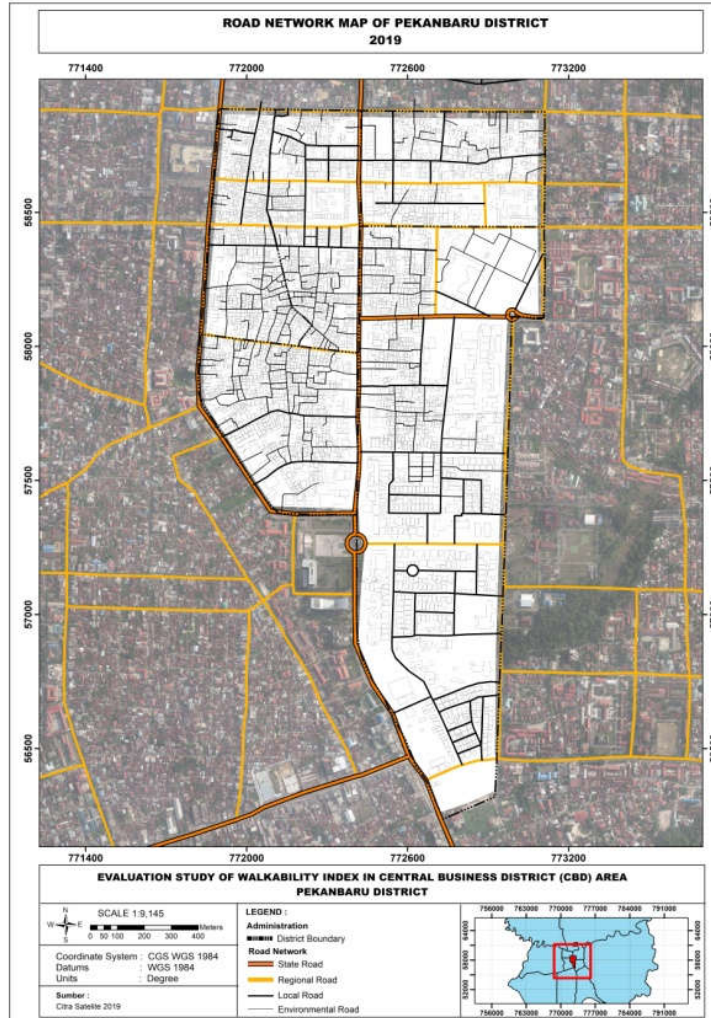


Fig1. Map of Road Network

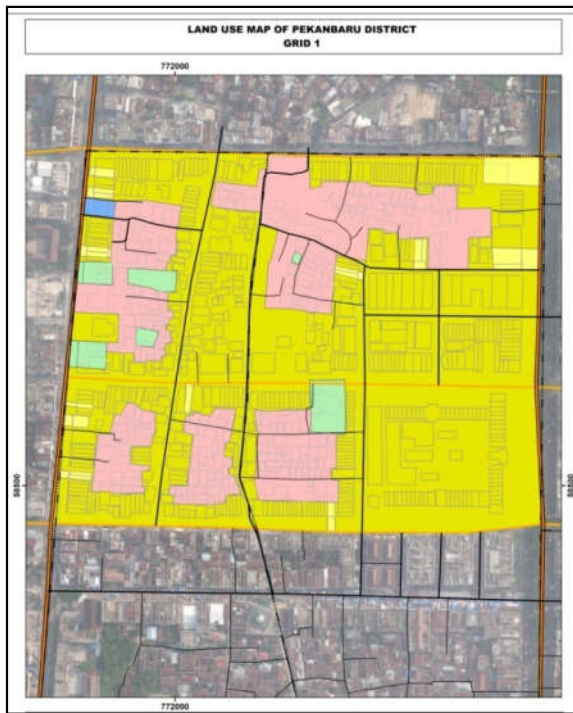


Fig 2. Map of Entropy Index Grid 1

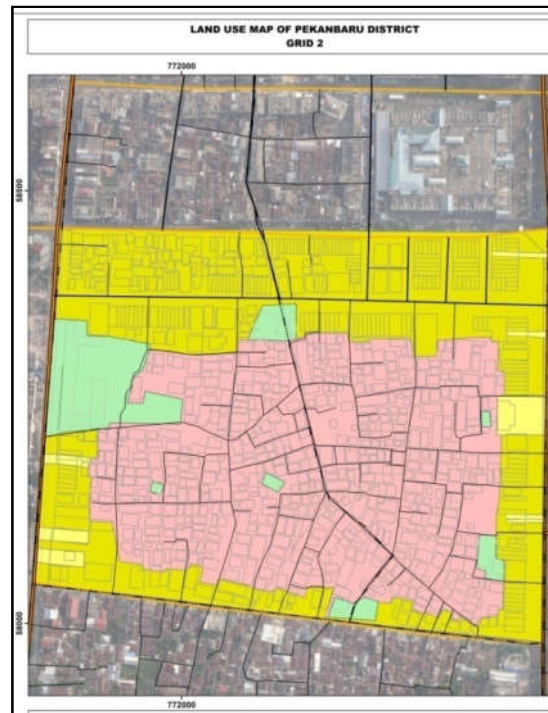


Fig 3. Map of Entropy Index Grid 2

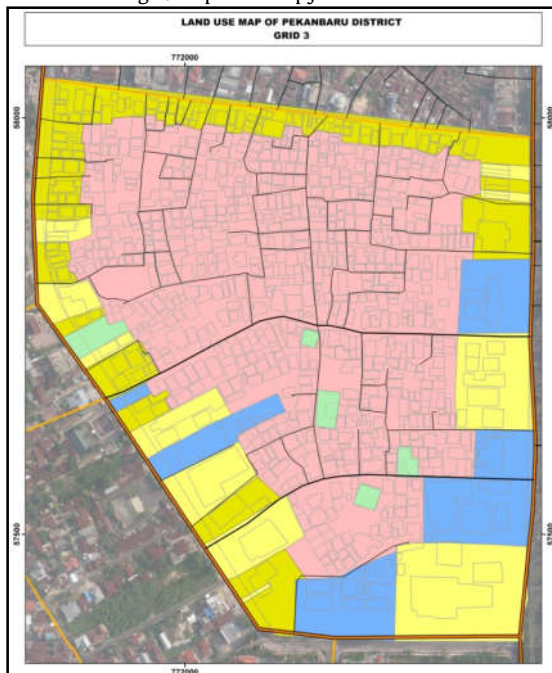


Fig 4. Map of Entropy Index Grid 3

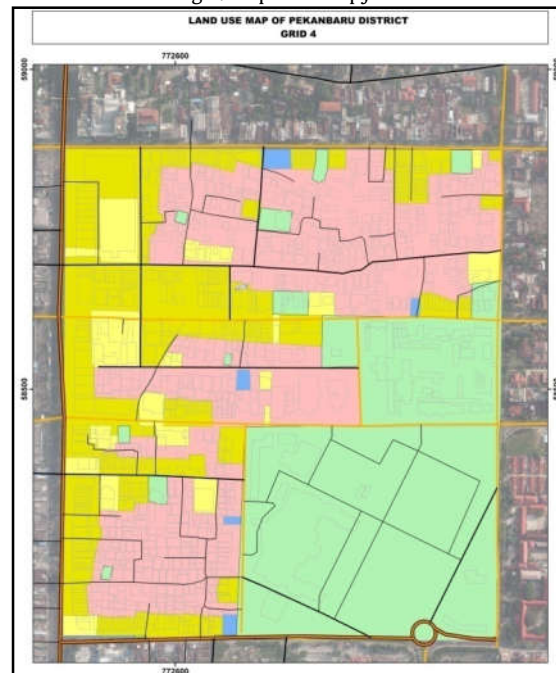


Fig 5. Map of Entropy Index Grid 4

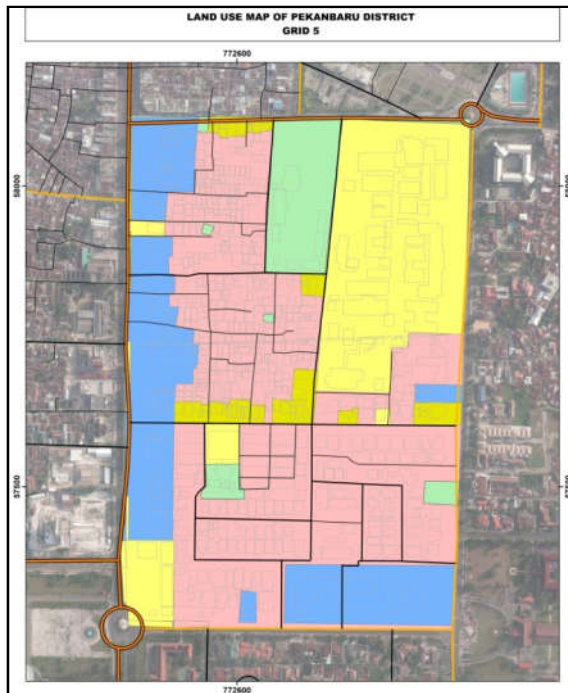


Fig 6. Map of Entropy Index Grid 5



Fig 7. Map of Entropy Index Grid 6

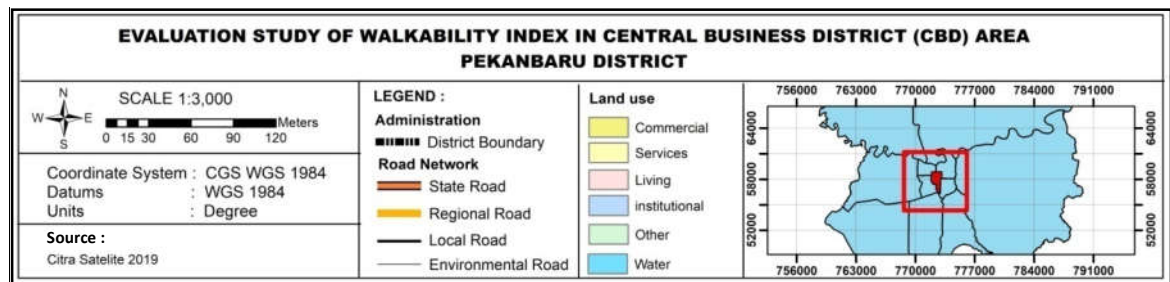


Fig 8. Legend of Map Entropy Index Grid 1, 2, 3, 4, 5, & 6.

value is a grid that has a ratio of unequal land-use floor area. On-grid 6 (the area around Jalan Diponegoro) there are up to 6 types of building/use functions, where each type of function has an area that contrasts with the area measured.

For grids that have the lowest Entropy Index values such as grid 1 (the area around Jl. HOS. Cokroaminoto) is dominated by housing and trade uses. And also grid 3 (the area around Bank Riau Kepri) is dominated by office and service activities. As well as grid 2 (the area around Jalan Ahmad Yani with Jalan Hidayat Jalan Jalan) which is only dominated by the functions of trading

5.3. FAR analysis

The existence of commercial areas is one of the important factors in encouraging people to walk. The commercial is a land use that has a high attractiveness because it offers many activities. The higher the value of the FAR index, the more diversity of commercial activities contained in the grid so that the more encouraging people to come to the place. Conversely, the lower the diversity of the functions of commercial activities are spread in the grid and do not encourage people to walk in the region.

Table 5. Region Grid FAR Index Value

Grid	C	Sum C	FAR	FAR(z-score)
1	112.434	350.819	0,32	1,5
2	89.128	350.819	0,254	0,853
3	35.224	350.819	0,1	-0,657
4	95.721	350.819	0,273	1,04
5	10.324	350.819	0,029	-1,353
6	7.988	350.819	0,023	-1,412
Average			0,167	
Standard Deviation			0,102	

From the results of calculations (Table 5), half of all grids do not have high FAR values such as grids 3, 5, and 6. These grids show that the FAR value is still low to make the area have a good level of walkability. While the other half contained in grid 1 (the area around Jl. HOS. Cokroaminoto), grid 2 (the area around Jalan Ahmad Yani with Jalan Hidayat) and grid 4. The three grids do have a high variant of commercial activity, where this place is located tall buildings and have a wide variety of activities. Grid 1 and grid 4 are the grids that have the most extensive commercial floor area compared to other grids. This grid also has a very high commercial density that allows people to carry out diverse activities in the region. Grid 1, grid 4

and grid 2 are passed by Jalan Sudirman which is the main road in Pekanbaru City. Grid 1 and grid 2 are Ramayana shops which are dense areas and vary in their commercial activities. In this research area, there

is a grid that has the largest concentration of commercial activities, which is indicated by the presence of city-scale shopping centers.

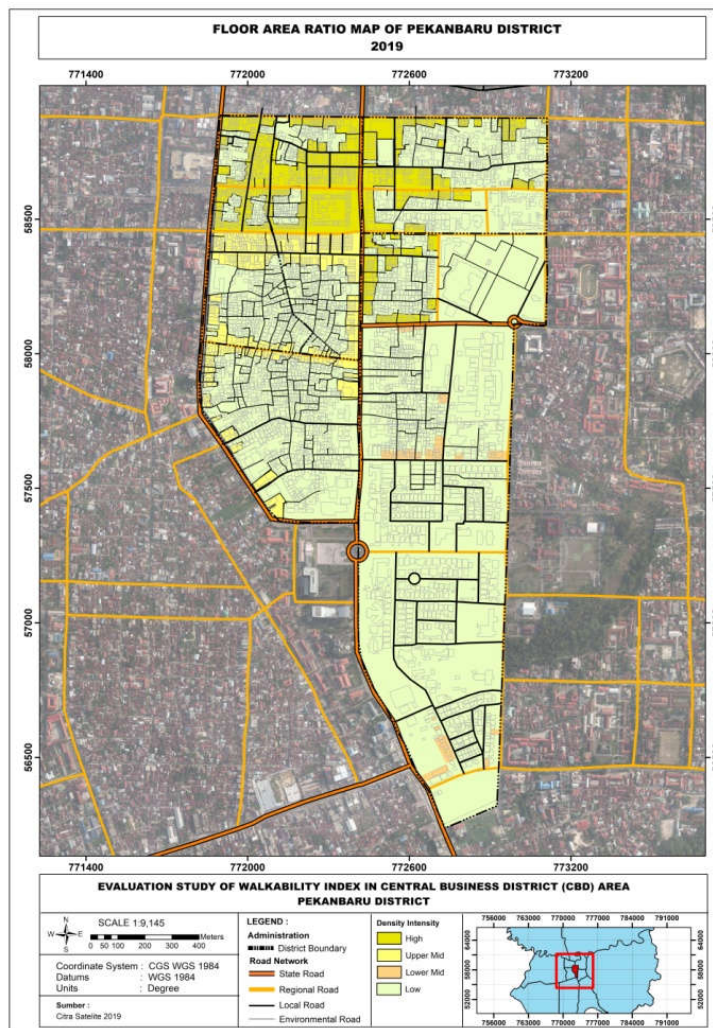


Fig 9. Map Floor Area Ratio (FAR)

5.4. Analysis of Household Density Index

The housing density is another important factor affecting the high level of the pedestrian in a city. The housing density is needed to provide the users needed to support transit, recreational and other facilities. These facilities tend to gather in densely populated areas. The lower the density of the house, the more distant facilities the community needs, so that the community will move far from its housing.

Table 6. District Hdens Grid Value

Grid	L (meter square)	Hdens (z-score)
1	76385	0,0736
2	200.579	0,1935
3	245.176	0,2365
4	231.115	0,223
5	189.653	0,183
6	93.765	0,09
Average		1,1666

The higher the density of housing the more dense housing units that have an impact on the high number of pedestrians and vice versa when the lower the density of housing the lower the number of pedestrians in the area.

The results of the H-dens calculation show that not all grids have a good density to make the area pedestrian-friendly. Grid 3, grid 4, grid 2 and grid 5 (in the highest order) have good housing density to encourage people to walk. While grid 1 and grid 6 have low H-dens Index values and indicate the area is not pedestrian-friendly. Grid 3, grid 4, grid 2, and grid 5 areas have high settlement densities and have many building blocks. While grid 1 and grid 6 are densely populated areas, the grid is dominated by trade and service activities. Even along Jalan Sudirman, there is a dominance of office and service activities, especially on grid 6.

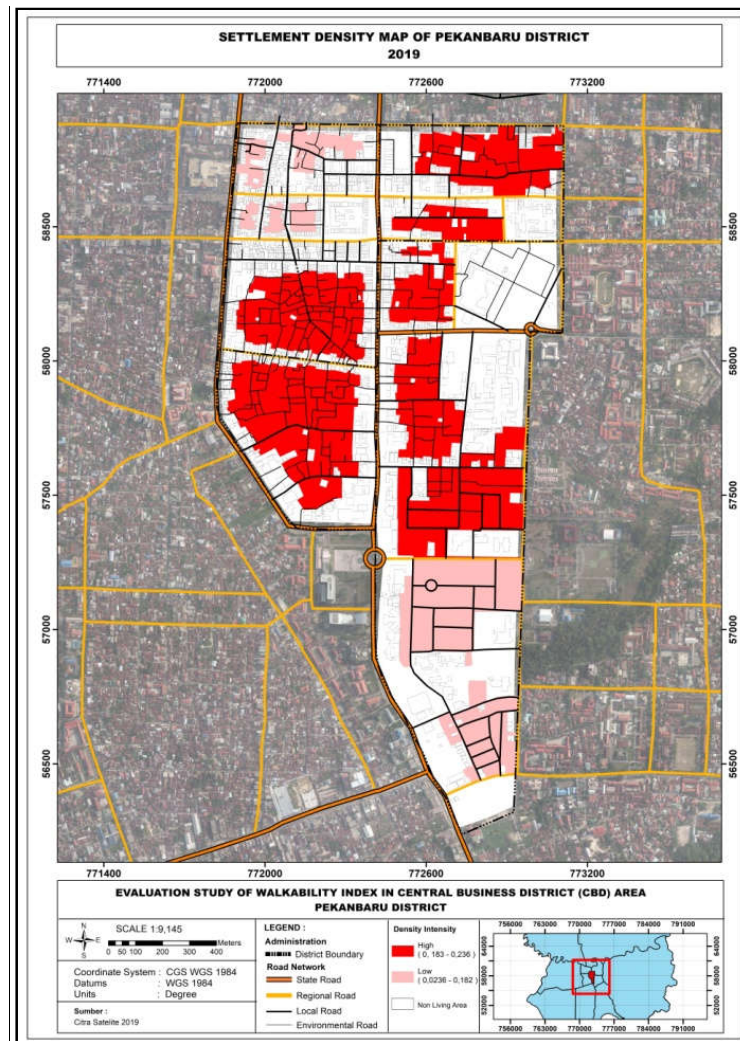


Fig 10. Housing Density Map

5.5. Pekanbaru City CBD Walkability Index

Each parameter in the grid is added based on the data obtained in the previous calculation. From the results obtained for each index, the variable is very

diverse, there is no one grid there is a positive value on each variable. The calculation of the Pekanbaru Kota Sub-District Walkability Index which is divided into grids is as follows: (Table.7)

Table 7. Value of Walkability Index Grid of CBD Area in Pekanbaru City

Grid	Z-con	2 x z-con	z-ent	z-FAR	z-Hdens	WalkabilityIndex
1	-2,041483	-4,082966	-1,407	1,5	0,0736	-3,916
2	6,941042	13,882084	-0,643	0,853	0,1935	14,286
3	6,124449	12,248898	-0,731	-0,657	0,2365	11,097
4	-4,164625	-8,32925	0,714	1,04	0,223	-6,352
5	-1,061571	-2,123142	0,819	-1,353	0,183	-2,474
6	-5,797812	-11,595624	1,242	-1,412	0,09	-11,675

Calculation results from the walkability index show that grid 2 (the area around Ahmad Yani Street with Jalan Hidayat section) has the highest walkability index and then the highest value is also on grid 3 (the area around Bank Riau Kepri). While grid 6 (the area around Jalan Diponegoro) has the lowest walkability index value of the six grids. Of all the grids, there are four grids that have a negative walkability index value, namely grid 1, grid 4, grid 5 and grid 6. The negative value indicates an area that has a poor walkability value.

The walkability index value in Pekanbaru Kota Sub-District has mixed results. The walkability index value in the CBD area of Pekanbaru City which is not so high and there are still many

negative value grids can be the basis for making conclusions that the level of walkability in general in Pekanbaru Kota Sub-District is still relatively low.

The area around Ahmad Yani Street with the Prince Hidayat Street (grid 2) has the highest walkability index value of all objects of the research area with an index value of 14,286. In this area, there are high

trading and service activities, especially the Ramayana shopping area which is used as a place to sell a variety of goods and basic needs of the community. The area has a high intensity of community movement. However, this value cannot be considered high enough to fully encourage the community to walk in the area. In fact the parameter that has a high value in the region is because the area has a good level of connectivity (connectivity index) and the number of commercial activities (FAR index), meanwhile, the value of other parameters such as regional diversity (entropy index) and housing density (H- dens) has a negative value. as well as the area around other grids which has an unbalanced walkability index value among its parameters, some grids excel at the connectivity level but are low in the FAR index parameters and vice versa. To achieve a good walkability index value, it is necessary to increase each of the parameters that make up the walkability.

Further analysis shows the pattern of walkability index values where areas that are dominated by office activities and services such as grid 1, grid 4, grid 5, and grid 6 have low walkability values. Meanwhile, areas that are more mixed-use have higher walkability index such as grid 2 and grid 3. From the results of data processing shows areas that have high walkability values, tend to have a comparison of diverse activities such as housing, commercial, and the number of intersections, and many buildings with mixed-use functions are found. This pattern is not much found in areas that are not dominated by trade or housing activities. Thus resulting in a low value of walkability, especially in areas that tend to be homogeneous activities.

5.6. Evaluation of the Walkability Concept in the Pekanbaru City Sub-District Area

The IPEN Project Walkability Concept is a concept for assessing the walkability index of an area from the perspective of an urban form. The urban form perspective consists of three variables: population density, road network patterns, and land-use diversity. This theory emphasizes that the walkability of an area depends on land use and accessibility within the region. IPEN Project as a derivative concept from the urban form perspective evaluates the walkability of the number of intersections, proportional land use, commercial floor area population, and housing density. The findings of several studies indicate that the walkability index is highly correlated with walking trips for most non-work travel destinations, although socio-demographic characteristics also play a key role. In addition, households with more mobility choices are more sensitive to their environment than households with fewer mobility choices. This finding highlights the fact that the walkability index will not have the same correlation with travel behavior for all individuals or households (Manaugh and El-Geneidy, 2011).

This concept has a tendency to prioritize the use of commercial and residential land compared to other land uses. In the theory of urban form, the intended land use is a variety of land uses without inclining to

certain activities. Pekanbaru Kota Subdistrict has a very diverse designation of areas such as commercial, offices, housing, government agencies, and other activities. The results of the assessment can be illustrated by the walkability index value of the CBD area of Pekanbaru City which has different values in each region/grid. In general, the value of the walkability index in the Pekanbaru City Subdistrict has a negative average value, which means the environmental conditions of the Pekanbaru City CBD area are still not friendly to pedestrians. This is indicated by the existence of four grids out of the six existing grids which have negative values. This condition allows for improvements related to some parameters that have a bad value.

From some previous studies, there is a positive and stratified relationship between environmental walkability and the desire to walk. Residents in more walkable environments present a higher percentage chance of walking in transportation compared to those who live in less walkable areas (Ribeiro and Hoffmann, 2018). The addition of commercial floor area is an action that is still possible, it does not significantly make the area walkable. But it is necessary to redesign the road network to improve the walkability index ideally. Improving quality is difficult to do in areas that have been physically formed. Although to improve walkability from the urban form side it is very difficult to implement. But it can still be done to improve the quality of the environment that is friendly to pedestrians in Pekanbaru Kota Sub-District with development from another perspective, namely from the aspect of urban design (physical quality of the environment) or transportation (relations with other modes of transportation).

6. Conclusion

The walkability index value of Pekanbaru Kota Subdistrict measured by using the WAI IPEN Project model produces a variety of patterns of values based on the parameters measured. The area is divided into research which is divided into 6 grids to facilitate research in measuring the variables to be assessed. The results of the analysis show that grid 1, grid 4, grid 5, and grid 6 have negative walkability index values, whereas there are two regions that have positive results, namely grid 2 and grid 3. In the analysis of the walkability value patterns, it is seen that the area is dominated by agency activities/offices that have lower walkability values compared to dense residential areas with mixed-use patterns. Besides that walkability throughout the research area is not so prominent. Even so, the value of the walkability index in the study area still does not describe a friendly environment for pedestrians, so it is necessary to improve some forms of urban space in order to achieve the concept of a walkable city in the Central Business District (CBD) of Pekanbaru City.

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References

- Carlson, J.A., Saelens, B.E., Kerr, J., Schipperijn, J., Conway, T.L., Frank, L.D., Chapman, J.E., Glanz, K., Cain, K.L., Sallis, J.F., 2015. Association between neighborhood walkability and GPS-measured walking, bicycling and vehicle time in adolescents. *Heal. Place* 32, 1–7. <https://doi.org/10.1016/j.healthplace.2014.12.008>
- Dobesova, Z., Krivk, T., 2012. Walkability Index in the Urban Planning: A Case Study in Olomouc City. *Adv. Spat. Plan.* 3, 179–196. <https://doi.org/10.5772/36587>
- Forsyth, A., 2015. What is a walkable place? The walkability debate in urban design. *Urban Des. Int.* 20, 274–292. <https://doi.org/10.1057/udi.2015.22>
- Forsyth, A., Southworth, M., 2008. Cities afoot - Pedestrians, walkability and urban design. *J. Urban Des.* 13, 1–3. <https://doi.org/10.1080/13574800701816896>
- Frank, L.D., Sallis, J.F., Saelens, B.E., Leary, L., Cain, L., Conway, T.L., Hess, P.M., 2010. The development of a walkability index: Application to the neighborhood quality of life study. *Br. J. Sports Med.* 44, 924–933. <https://doi.org/10.1136/bjism.2009.058701>
- Jun, H.J., Hur, M., 2015. The relationship between walkability and neighborhood social environment: The importance of physical and perceived walkability. *Appl. Geogr.* 62, 115–124. <https://doi.org/10.1016/j.apgeog.2015.04.014>
- Krambeck, H., Shah, J.J., 2006. The Global Walkability Index. Massachusetts Institute of Technology.
- Leslie, E., Coffee, N., Frank, L., Owen, N., Bauman, A., Hugo, G., 2007. Walkability of local communities: Using geographic information systems to objectively assess relevant environmental attributes. *Heal. Place* 13, 111–122. <https://doi.org/10.1016/j.healthplace.2005.11.001>
- Lund, H., 2002. Pedestrian environments and sense of community. *J. Plan. Educ. Res.* 21, 301–312. <https://doi.org/10.1177/0739456X0202100307>
- Manaugh, K., El-Geneidy, A., 2011. Validating walkability indices: How do different households respond to the walkability of their neighborhood? *Transp. Res. Part D Transp. Environ.* 16, 309–315. <https://doi.org/10.1016/j.trd.2011.01.009>
- Moura, F., Cambra, P., Gonçalves, A.B., 2017. Measuring walkability for distinct pedestrian groups with a participatory assessment method: A case study in Lisbon. *Landsc. Urban Plan.* 157, 282–296. <https://doi.org/10.1016/j.landurbplan.2016.07.002>
- Owen, N., Humpel, N., Leslie, E., Bauman, A., Sallis, J.F., 2004. Understanding environmental influences on walking: Review and research agenda. *Am. J. Prev. Med.* 27, 67–76. <https://doi.org/10.1016/j.amepre.2004.03.006>
- Owens, P.M., 1993. Neighborhood form and pedestrian life: Taking a closer look. *Landsc. Urban Plan.* 26, 115–135. [https://doi.org/10.1016/0169-2046\(93\)90011-2](https://doi.org/10.1016/0169-2046(93)90011-2)
- Pivo, G., Fisher, J.D., 2011. The walkability premium in commercial real estate investments. *Real Estate Econ.* 39, 185–219. <https://doi.org/10.1111/j.1540-6229.2010.00296.x>
- Ribeiro, A.I., Hoffmann, E., 2018. Development of a neighbourhood walkability index for porto metropolitan area. How strongly is walkability associated with walking for transport? *Int. J. Environ. Res. Public Health* 15. <https://doi.org/10.3390/ijerph15122767>
- Rodríguez, D.A., Khattak, A.J., Evenson, K.R., 2006. Can new urbanism encourage physical activity? Comparing a new urbanist neighborhood with conventional suburbs. *J. Am. Plan. Assoc.* 72, 43–54. <https://doi.org/10.1080/01944360608976723>
- Saelens, B.E., Sallis, J.F., Black, J.B., Chen, D., 2003. Neighborhood-Based Differences in Physical Activity: An Environment Scale Evaluation. *Am. J. Public Health* 93, 1552–1558.
- Saelens, B.E., Sallis, J.F., Frank, L.D., Cain, K.L., Conway, T.L., Chapman, J.E., Slymen, D.J., Kerr, J., 2012. Neighborhood environment and psychosocial correlates of adults' physical activity. *Med. Sci. Sports Exerc.* 44, 637–646. <https://doi.org/10.1249/MSS.0b013e318237fe18>
- Van Holle, V., Van Cauwenberg, J., Van Dyck, D., Deforche, B., Van de Weghe, N., De Bourdeaudhuij, I., 2014. Relationship between neighborhood walkability and older adults' physical activity: Results from the Belgian Environmental Physical Activity Study in Seniors (BEPAS Seniors). *Int. J. Behav. Nutr. Phys. Act.* 11, 1–9. <https://doi.org/10.1186/s12966-014-0110-3>



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