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AN URBAN FORM STUDY ON WALKING CHOICE (A CASE STUDY IN THE CENTRAL BUSINESS DISTRICT JENDERAL SUDIRMAN, PEKANBARU)

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ABSTRACT

Urban form and walking choice have complex relationships. Initial research has shown some drawbacks, uncertainties, and no inclusive results regarding the impact of urban form on walking choice since previous studies disregard walking purposes (utilitarian, transit, and non-utilitarian). The quantitative approach uses a statistical analysis and scoring index from the International Physical Activity and Environmental Project, while the qualitative approach applies a descriptive-analytic to describe travel behaviour and preference. The aims of this research are (1) to measure the walkability index with the urban forms approach, (2) to analyze the travel preference, travel behaviour for walking choice, (3) to see the effect of urban form on walking choice. The results showed that only two areas are walkable (Grid 2 with WAI 4,58 and Grid 5 with WAI 0,87). Meanwhile, the rest of the grids remained negative and had very low walkability indicators. Regarding walking preference, 63.40% of respondents contributed to non-active walking choice, whereas only 36.6% accounted for walking as their basic transportation mode. Interestingly, nearly 50% of walking preferences are done for non-utilitarian purposes since walking is still needed to keep their bodies healthy. Besides, the urban form variables have differently impacted on walking choice purposes. Firstly, walking for utilitarian purposes has been affected by entropy (P>{z} 0.049), floor area ratio (P>{z} 0.039), and household density (P>{z} 0.038). Therefore, walking for transit purposes has been influenced by connectivity (P>{z} 0.039), whereas walking for non-utilitarian purposes has been affected by household density (P>{z} 0.031).

Keyword : surban form, utilitarian, transit, non-utilitarian, walkability

ABSTRAK

Bentuk kota dan pemilihan moda berjalan kaki memiliki hubungan yang kompleks. Penelitian sebelumnya menunjukkan kelemahan, ketidakpastian, dan tidak adanya hasil yang jelas terkait bagaimana pengaruh bentuk kota terhadap pemilihan moda berjalan kaki. Hal ini disebabkan karena tidak mempertimbangkan jenis-jenis pelaku pejalan kaki (utilitarian, transit, non-utilitarin). Penelitian ini menggunakan metoda kombinasi, yaitu metoda kuantitatif dengan teknik analisis dan rumus indeks berjalan kaki dari IPEN Project dan analisis skoring untuk melihat klasifikasi tingkat berjalan kaki. Kemudian, metoda kualitatif menggunakan teknik analysis statistic deskriptif dengan distribusi frekuensi terkait perilaku perjalanan dan pemilihan moda transportasi. Penelitian ini bertujuan untuk (1) mengukur indeks berjalan kaki dengan pendekatan bentuk kota, (2) menganalisis pemilihan perilaku perjalanan, (3) menganalisis pengaruh bentuk kota terhadap pemilihan moda berjalan kaki. Hasil analisis terlihat bahwa hanya 2 area saja yang termasuk ramah bagi pejalan kaki (Grid 2 dengan WAI 4,58 dan Grid 5 dengan WAI 0,87). Kemudian, hanya 36.6% responden yang menjawab berjalan kaki sebagai moda transportasi utama, sementara sisanya menggunakan kendaraan. Menariknya, 50% responden berjalan kaki untuk tujuan olahraga dan rekreasi (non-utilitarian) dengan alasan menjaga tubuh agar tetap sehat. Variabel bentuk kota yang mempengaruhi pejalan utilitarian adalah entropi (P>{z} 0.049),, lantai bangunan (P>{z} 0.039), dan kepadatan permukiman (P>{z} 0.038). Pejalan kaki transit hanya dipengaruhi oleh konektivitas (P>{z} 0.039) dan pejalan kaki non-utilitarian hanya dipengaruhi oleh kepadatan permukiman (P>{z} 0.031).

Kata kunci : Bentuk kota, pejalan kaki utilitarian, transit, non-utilitarian, walkability

1. INTRODUCTION

Previous studies have shown many critics and debates in urban form since it failed to encourage cities to be walkable, raising social segregation, causing environmental degradation and economic inequality (Alberti et al., 2007; Beatley et al., 1993; Coppola et al., 2014; Heckman et al., 1999; Jabareen, 2006; US EPA, 2001; Williams, 2001). Ironically, many recent city developments implicitly encourage civic society to use motorbikes, longer travel distances, and travel switching to motorized transportation instead of using public transport in city areas. Therefore, motorbike usages and ownerships in middle to low-income households also show an upward trend in developing countries (Boulange et al., 2017; Handy & Clifton, 2001; Lee, 2020; Pickrell, 2015; Wang & Zhang, 2021). Sadly, active transportations like walking and cycling have significantly decreased in urban areas (Boulange et al., 2017; Herrmann-Lunecke et al., 2021; Ozawa et al., 2021). Generally, it has been debated whether the study of urban form has a specific effect on urban sustainability, especially concerning how urban form could encourage the social community to walk as their daily mobility and help decline motorbike usage (Gim, 2015; Report, 2020). In addition, the study about the correlation between urban form and walking choice has not been identified clearly and remains uncertain since previous studies only studying from the perspective of travel preference, demand theory of walking mode, and travel route choice (Alawadi, 2017; Bauman et al., 2002; Coppola et al., 2014; Crane, 1996; Hidayati et al., 2021; Hou, 2019)

In the last years a substantial body of literature was devoted to the factors mediating human physical activity, as it is essential for the health and well-being of individuals and societies, however the theoretical mechanisms that lead to the decision of undertaking activity are not obvious. Numerous theories are used to create the framework for understanding physical activity, however the majority of the approaches focus on the individuals and their intentions to engage in activity, for example, social cognitive approach or the humanistic approach (Rhodes et al., 2019). In contrast, the socioecological model explains behaviour through the environment and policy, which contributed to its popularity in urban studies. According to that model, human behaviour in general is influenced by numerous levels of factors including individual, interpersonal, environmental and policy related (Berisha et al., 2012). Drawing from the socioecological theory different studies suggest that physical activity including walking may be affected, among others, by built environment characteristics such as proximity of homes and other destinations or good access to attractive open spaces. Consequently, urban form is perceived as a factor which can support and facilitate the choice of active modes of transport.

Significantly, the discussion on walkability a significant contribution comes from the work of urban designers and practitioners. According to the observations in a high-quality neighbourhood different types of activities may take place including meetings, watching other people and taking part in public life. At the same time, low quality in particular car-oriented neighbourhoods discourages walking for other than necessary purposes.

Pekanbaru is the capital city of Riau Province, where the City Mayor has a vision to make Pekanbaru a Walkable City. Besides, pedestrian development has been started since 2019 to decline private vehicle usage. In fact, the number of motorbike usage shows a significant rise, reaching nearly 2.4 million in 2020, and it contributes to severe traffic jams, air pollution, and urban heat temperature. People still prefer to use a private vehicle rather than walking and using public transportation because the pedestrian path is usually occupied by traders and street vendors (Sofwan & Tanjung, 2020; Fathira, 2006). On the other hand, based on current observation, the pedestrian infrastructure does not satisfy their mobility, such as broken pedestrian path, occupied with street vendors, lack of vegetation and trees, disintegrated with public transportation, and unsafe for women and children. However, the government in Pekanbaru has made policies and programs to reduce the dependency on a motorcycle, such as car-free days, bike-to-work and bike-to-school programs, sidewalk improvements, and developing pedestrian facilities to attract more people to use public transportation.

The first pedestrian facility was built in the Central Business District Jenderal Sudirman, and this area is classified as a compact CBD site in Pekanbaru. Interestingly, this area has a wide range of land used which is pretty walkable for pedestrians. But, the condition of pedestrian facilities has slowly decreased since many irresponsible people stole and ruined the facilities. Therefore, Pekanbaru's Government has no evaluation and good management in maintaining public facilities. Consequently, although this area is classified as a compact site, it failed to encourage people to walk and use public transportation to visit this area. So, this research is likely to see the effect of urban form on walking choice for utilitarian, transit, and non-utilitarian purposes.

In conclusion, this research aims to (1) measure the walkability index in the CBD area Jenderal Sudirman based on International Physical Environmental Project (IPEN), (2) analyze the travel preference and travel behaviour, and (3) measure the effect of urban form on walking choice from utilitarian, transit, and non-utilitarian purposes.

2. METHODOLOGY

2.1 Measures

The analysis applies to measuring walkability index in the Central Business District Jenderal Sudirman is supported by GIS (geographical information system). Geographic Information Systems (GIS) is a useful software for processing spatial data from the urban environment. GIS processes spatial (graphic) data and census data in the urban units (Dobesova & Krivk, 2012). In this research, this software will measure entropy, connectivity, floor area ratio, and household density in creating and maintaining urban plans. The previous study also used a GIS analysis to explore the relationship between open space systems and urban form for the adaptive capacity of cities after an earthquake (Villagra et al., 2014). Therefore, ArcScene software is also applied to make a 3D Dimension of Building Coverage in the study area. The data and variables in this research are;

Table 1. Data and Variable

No	Category	Data	Variable
1	Urban Form (Dobesova & Krivk, 2012).	Connectivity	1. Number of intersections in a grid/block
		Entropy	2. Land-use type in a grid 3. The total land use type in a grid 4. Land-use activities in a grid
		Floor Area Ratio	5. Commercial building area 6. Total commercial building area 7. Building Height (number of floors)
		Household Density	8. House building area 9. Total housing area
2	Walking Choice (Yang, 2016)	Walking for utilitarian purposes	10. Frequency of walking to work or school
		Walking for Transit purposes	11. Frequency of walking and using public transportation as a transit mode to reach destinations
		Walking for Transit purposes	12. Frequency of walking to do sport, recreation, and other leisure activities

Source: Many literatures, 2021

2.1.1 Walkability Index from IPEN Project

The International Physical Activity and Environment (IPEN) project is applied to see the walkability score in the CBD area with urban form variables (Dobesova & Krivk, 2012). The variables which represent the urban form indicators are (1) connectivity, (2) entropy, (3) housing density, and (4) floor area ratio. Below is the description regarding the indicator of the IPEN Project:

a. Connectivity index (Con): the connectivity is also called intersection density, where it measures the number of intersections per sub-area or square per 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 five years or satellite imagery in the latest year will be made into a road network map. In contrast, the highway is excluded from the input data because it is not suitable to pass or cause pedestrian injuries. On the other hand, the area of water bodies and

rivers is reduced from the site of the city unit. In terms of calculation, every intersection is given a valence value, which indicates the number of streets that meet at a particular corner. The "T" shaped crossroad has a valence value of three; an "X" shaped four. High values of the Connectivity index represent that the assessed area is well interconnected. The connectivity index is calculated using a formula derived from (Dobesova & Krivk, 2012). The formula is:

$$con = \frac{\sum intersections}{1\ km^2}$$

where;

- Con: connectivity index

b. Entropy index: this index indicates how homogenous or heterogeneous the usage of a particular area is. The higher is the diversity of the land use; the higher is the Entropy index. Good entropy index calculation is a high-quality land use polygon layer. The land-use types are divided as follows:

Table 2. The Category of Land Use Category

Category	Code
Living	L
Commercial	C
Services	S
Industrial	I
Institutional	T
Recreational	R
Other	O
Water	W

Source : Dobesova, Z., & Krivk, T. (2012)

In general, the distribution of residential, commercial, and office building floor areas is the best for physical activity. If the value of entropy is high for a given district, it probably can carry out all everyday activities within a relatively small area without having a longer travel distance or compact neighborhood. On the other hand, they could easily do working, shopping, schooling, and seeking entertainment within this district. The connectivity formula is:

$$H\ (S) = \frac{\sum_{i=1}^{k}(Pi).(lnPt)}{\ln k}$$

Where;

- H(S)= entropy index
- Pi= area ratio for each land–use category toward the total area of all categories
- k= number of existing land use categories

c. Housing density (Hdens):

The housing index represents the area's density and shows the possible walking distance to another land use, or it provides information about the number of households in every urban unit to calculate the household density (polygon geometry). The number of households is classified by the area intended for living in the urban unit. The second necessary input is again the land use type (as it was for the entropy index). Only zones tagged as L (living) are taken into account. The index reflects the form of living in an urban district. The high value represents a high density of households. Such values are typical for the city centers, where distances are suitable for walking. So, this criterion is applied to determine the level of housing density in an area. The household density formula is:

$$H\ dens = \frac{\sum Housing\ Building\ Area}{\sum Total\ Housing\ Area}$$

d. Floor Area Ratio (FAR):

The FAR index represents the ratio of shop buildings to the area of land use category labeled as commercial. It is estimated that a high index shows that the place has a significant percentage of smaller retail shops. Such a district will surely be more attractive for walking than the others. When the FAR index has a low value, there are probably more large shops and shopping malls with extensive car parks. Therefore, it is more convenient to use a car to go shopping. The formula is:

$$\text{far} = \frac{\sum Commercial\ Building\ Area}{\sum\ Total\ commercial\ \ Area}$$

e. Walkability index (WAI)

The Walkability index is obtained by calculating the entropy index, FAR index, household density, and connectivity parameter. Following that, all partial indexes are calculated for the individual layer of urban districts. A set of partial indexes is assigned to every row of the table of urban districts. The formula of the walkability index is:

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

Where;

- WAI = *Walkability index*
- *con =Connectivity index*
- *ent = Entropy index*
- *far* = FAR *index*
- *hdens = Housing density index*

2.1.2 Urban Form and Walking Choice

In this research, the main element of urban form has been adopted from the IPEN project (Dobesova & Krivk, 2012), where it consists of (1) entropy index, (2) floor area ratio, (3) housing density, (4) and connectivity index. In addition, those variables are likely to be deeply studied in the central business district Jenderal Sudirman to see the effect of urban form indicators on walking choice. At this point, the walking choice consists of (1) utilitarian, (2) transit, and (non-utilitarian) purposes. A utilitarian walker is a person who is classified as a full-fledged pedestrian from their home/origin to the workplace or to school, where is usually affected by the distance and condition. Meanwhile, a transit walker is a person who takes a walk to the bus shelter, then gets into public transportation and walks again to reach the destination (workplace). Besides, a non-utilitarian pedestrian is a person categorized as a non-active walker who usually rides in a private transportation mode or a person who only takes a walk for leisure activities or sports activities. The chi-square analysis will be applied to see the effect and correlation of urban form on walking choice (utilitarian, transit, and non-utilitarian). Therefore, this analysis also determines the significant variables on walking choice decisions. The formula is:

$$X^2 = \sum_{i=1}^{k} \frac{(fo-fh)2}{fn}$$

Where;

X^2 = chi square

Fo = frequency of observation

Fn = frequency of expectation

2.2 Statistical Analysis

2.2.1 Descriptive Statistical analysis

The descriptive statistical analysis is applied to measure the walkability index from the IPEN project using a Likert scale. The Likert scale is classified into three stages, they are (1) green level (WAI > 70), (2) yellow level (WAI 50-70), and red level (WAI <50). Therefore, the descriptive analysis will also apply to explain (1) travel choice, (2) preference, (3) travel safety and security, (4) and walking experience in the CBD Jenderal Sudirman. Afterward, according to the questionnaire, there are likely explanations regarding the effect of urban form on walking choice.

3. RESULTS AND DISCUSSIONS

3.1 Walkability index from IPEN Project

The walkability index from IPEN Project is a systematic calculation that measures the connectivity, entropy, floor area ratio, and housing density, or is concerned in urban form indicators. The formula is:

$$WAI = (2*(z\text{-}con)) + (z\text{-}ent) + (z\text{-}FAR) + (z\text{-}Hdens)$$

Where;

- WAI: Walkability Index
- z-con: Standard value of connectivity index
- z-ent: Standard value of entropy index
- z-FAR: Standard value of FAR index
- z-Hdens: Standard value of household density index

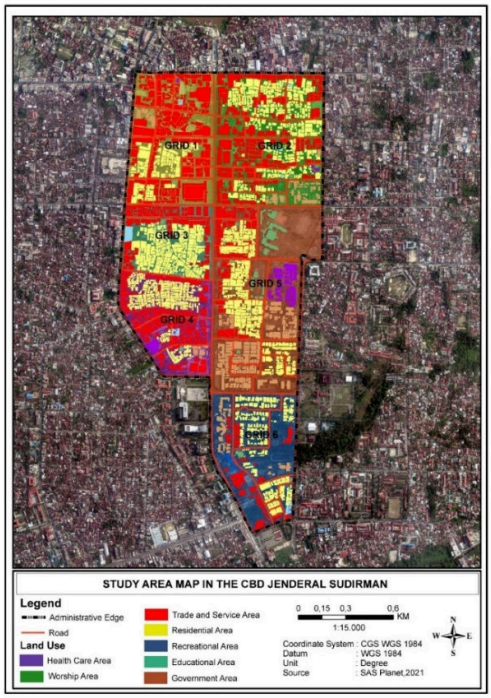

Figure 1. Study Area Map
Source: Observation and SAS Planet, 2022

3.1.1 Entropi Index

The entropy index represents the variety of land use in an area. Generally, pedestrians are likely to walk to a place that offers many different destinations and activities rather than rigid zoning. Numerous studies report that higher densities, mixed land uses, more open circulation patterns, and pedestrian-"friendly" environments are all associated with less car travel. Consequently, mixing uses ensures that many services are within a reasonable distance, thus encouraging cycling or walking (Alawadi, 2017).

According to the entropy analysis at the CBD Jenderal Sudirman area, it shows that good and positive entropy index contributed to Grid 3 (z-score 1,177), grid 4 (z-score 1,119), and Grid 6 (z-score 0,035). Indeed, Grid 3 is the highest entropy index in the CBD area since it has a proportionally land-use percentage and provides many land-use activities. In contrast, the negative entropy index accounts for grid 1 (z-score -0.853), grid 2 (z-score -1.260), dan grid 5 (z-score -0.219). Interestingly, the variety of land use in these areas are quite varied, but it does not proportionally distribute in each area, such as in grid 5, where the dominant land used are for small retail and services, bank, and hotel, which covers more than half of the total area, and only provides nearly 15% for public services. As a result, it makes the entropy index becomes negative and less desirable for pedestrians. Below table 3 shows the entropy index;

Table 3. Entropy Index in The CBD Area Jenderal Sudirman

Grid	Area (M2)	Index	Average	Deviation Standard	Z-Score
1	447907	0,066	0,099	0,039	-0,853
2	580289	0,050	0,099	0,039	-1,260
3	255151	0,145	0,099	0,039	1,177
4	319006	0,143	0,099	0,039	1,119
5	701523	0,091	0,099	0,039	-0,219
6	396586	0,101	0,099	0,039	0,035

Source: Analysis, 2022

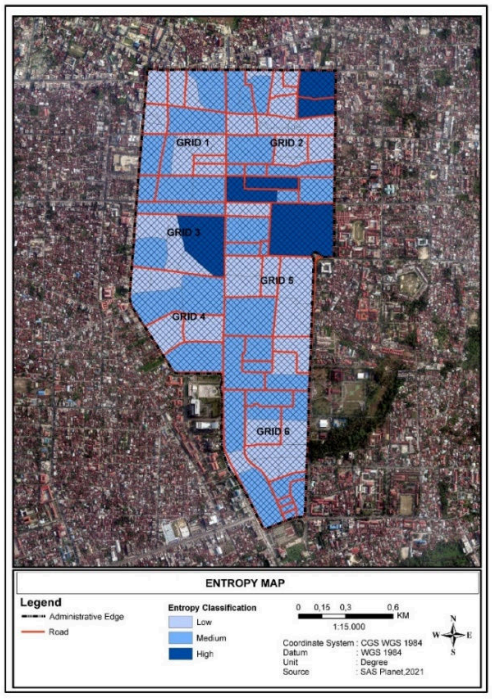

Figure 2. Entropy Index Map
Source: Analysis, 2022

3.1.2 Floor Area Ratio (FAR) Index

The floor area ratio compares the total building of commercial shops and the entire grid area. In terms of processing, the availability of retail or commercial stores is a crucial factor in encouraging someone to have a walking decision since it has been successfully causing trip attraction and provides many different activities and services that are certainly attractive for walkers.

According to the FAR analysis, the areas that have high intensities and commercial stores are in grid 1 (Z-score 1,394), grid 2 (Z-score 1,005), and grid 4 (Z-score 0,001). These areas have a significant number of retail stores such as fruit markets, groceries, clubs, barbershops, small shops near the Pekanbaru Mall, and retail shops in Senapelan Plaza. More than 60% of the total area in grid 1, grid 2, and grid 4 are occupied by trading activities, attracting more pedestrians to visit the CBD Jenderal Sudirman. Consequently, these areas trigger traffic jams and severe air pollution, unsafe for pedestrians. On the other hand, the areas which have a negative index contributed to grid 3 (Z-score -0,549), grid 5 (Z-score -0.838), and grid 6 (Z-score -1,022), where these areas have little commercial building and provide more housing to the middle and low-income household. Below table 4 explains the FAR index;

Table 4. FAR Index in The CBD Area Jenderal Sudirman

Grid	Trade & Service Area (M2)	Grid Area (M2)	Average	Standard Deviation	Z-Score
1	177757,1736	447907,000	93451,675	60489,457	1,394
2	154229,7408	580289,000	93451,675	60489,457	1,005
3	60222,757	255151,000	93451,675	60489,457	-0,549
4	94089,338	319006,000	93451,675	60489,457	0,011
5	42757,736	701523,000	93451,675	60489,457	-0,838
6	31653,303	396586,000	93451,675	60489,457	-1,022

Source: Analysis, 2022

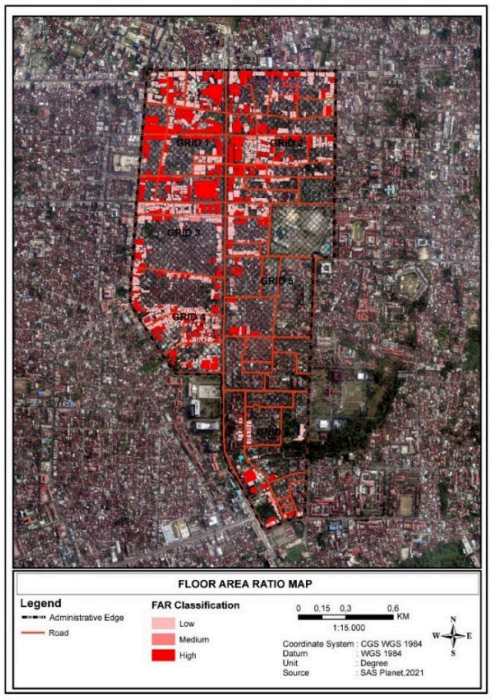

Figure 3. Floor Area Ratio Map
Source: Analysis, 2022

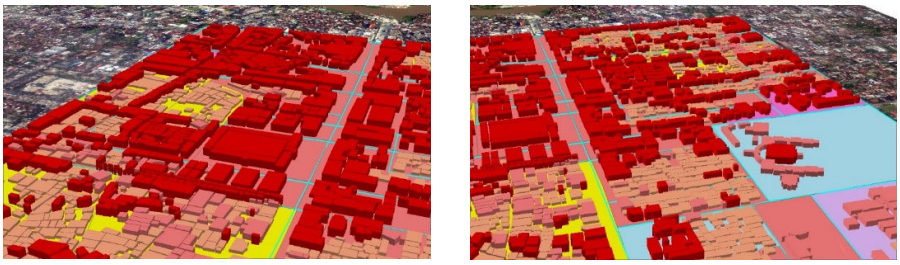

Figure 4 Floor Area Ratio Design in Grid 1 and Grid 2
Source: Analysis, 2022

Figure 5 Floor Area Ratio Design in Grid 3 and Grid 4
Source: Analysis, 2022

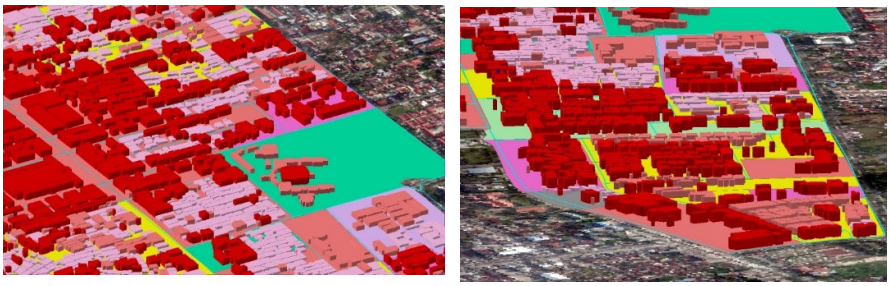

Figure 6 Floor Area Ratio Design in Grid 5 and Grid 6
Source: Analysis, 2022

3.1.3 Household Density Index

Household Density is a critical typology in determining sustainable urban forms. Besides, it is the ratio of people or dwelling units to land area. The relationship between density and urban character is also based on the concept of viable thresholds. At specific densities (thresholds), the number of people within a given area becomes sufficient to generate the interactions needed to make urban functions or activities viable (Kumakoshi et al., 2021; Rodríguez-Álvarez, 2014, p. 114).

Based on the household density index, the areas which have better and positive density is in grid 2 (Hdens Z-score 1,446), grid 3 (Hdens Z-score 0,231), grid 5 (Hdens Z-score 0,796), where these grids have a large population and are classified as a fast developing area in Pekanbaru since it is closely located in the capital district. The housing type in these areas is dispersed, disorganized, and individual residential areas densely occupied with low-income households. Typically, these locations are also supported by social and public facilities, such as primary and secondary schools, local sports areas, city mayor's office, regional private enterprises, banks, trade and service activities. Nonetheless, the sites in grid 1 (Hdens Z-score -1,170) and grid 4 (Hdens Z-score -0,609) represent the low household density now that the land is dominantly used for trading activities and green areas. Below table 5 provides a household density index;

Table 5. Household Density Indeks in The CBD Area Jenderal Sudirman

Grid	Residential Area	Grid Area (M2)	Average	Standard Deviation	Z-Score
1	48239,0114	447907,000	82476,428	29270,594	-1,170
2	124806,436	580289,000	82476,428	29270,594	1,446
3	89239,361	255151,000	82476,428	29270,594	0,231
4	64661,957	319006,000	82476,428	29270,594	-0,609
5	105777,198	701523,000	82476,428	29270,594	0,796
6	62134,606	396586,000	82476,428	29270,594	-0,695

Source: Analysis, 2022

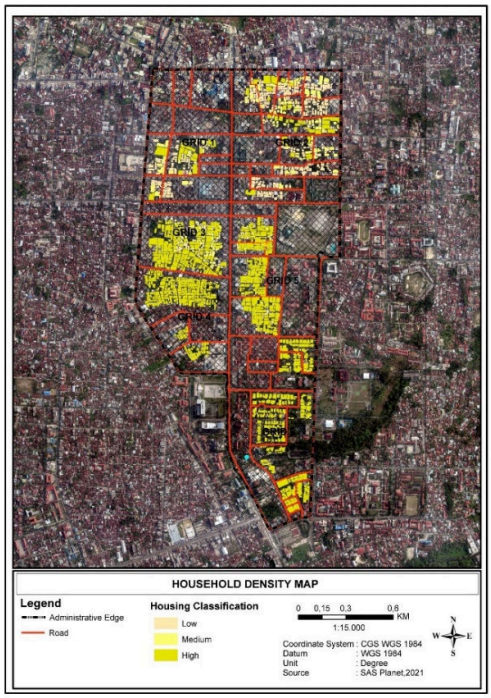

Figure 7. *Household Density Map*
Source: Analysis, 2022

3.1.4 Connectivity Index

Generally, compactness also refers to urban continuity (and connectivity), which suggests that future urban development should be adjacent to existing urban structures (Adolfsson et al., 2021). When the concept is applied to existing rather than new urban fabric, it refers to the containment of further sprawl rather than reducing the present sprawl (Altarans & Pradoto, 2019; Wolff et al., 2018). The compactness of urban space can minimize energy, water, materials, products, and people mobility (Boulange et al., 2017)

On average, the connectivity index showed that almost every grid have a very low connectivity value (Grid 1, Grid 3, Grid 4, Grid 5) since it is used for private buildings and stores, and many pedestrian ways are occupied by traders or street vendors, making the pathway narrow and uncomfortable. Therefore, in these grids, dwellers usually do not work near their homes and thus have to travel a longer distance, which can not be done by active transport (on foot). Interestingly, only grid 2 (Con Z-score 1,692) and grid 6 (Con Z-score 0,000) have a slightly better and positive index compared to other grids in as much as these areas are dominantly used for residential areas with better pedestrian connectivity facilities.

Table 6. *Connectivity Index in The CBD Area Jenderal Sudirman*

Grid	Nodes	Grid Area (M2)	Average	Standard Deviation	Z-Score
1	48	447907,000	59	23,048	-0,477
2	98	580289,000	59	23,048	1,692

3	40	255151,000	59	23,048	-0,824
4	37	319006,000	59	23,048	-0,955
5	72	701523,000	59	23,048	0,564
6	59	396586,000	59	23,048	0,000

Source: Analysis, 2022

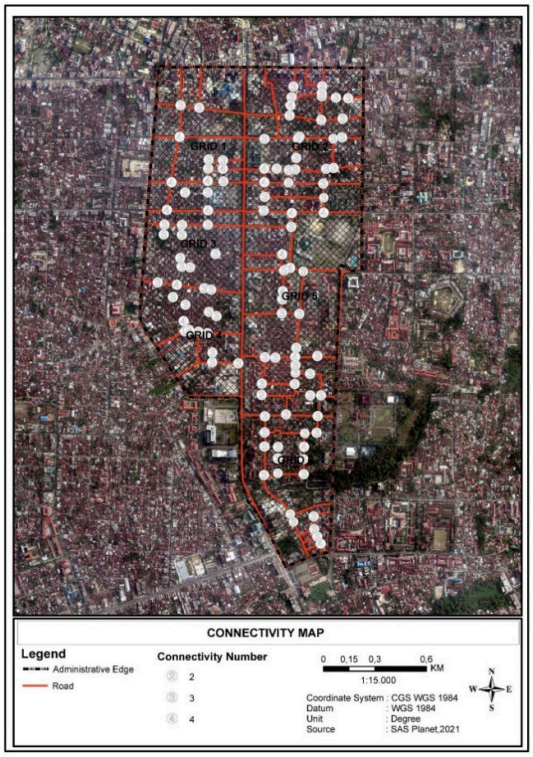

Figure 8. *Connectivity Map*
Source: Analysis, 2022

3.1.5 Walkability Index

The score of the walkability index is achieved from the calculation of all variables; there are (1) entropy, (2) floor area ratio, (3) household density, and (4) connectivity. Every indicator in grid 1- grid 6 will be calculated according to the analysis results. Below table 7 illustrates the walkability score in the CBD area Jenderal Sudirman;

Table 7. Walkability Score in The CBD Area Jenderal Sudirman

Grid	En Z-Score	Con Z-Score	Far Z-Score	Den Z-Score	WAI
1	-0,853	-0,477	1,394	-1,170	-1,58304
2	-1,260	1,692	1,005	1,446	4,575579
3	1,177	-0,824	-0,549	0,231	-0,79018
4	1,119	-0,955	0,011	-0,609	-1,38806
5	-0,219	0,564	-0,838	0,796	0,867165
6	0,035	0,000	-1,022	-0,695	-1,68146

Source: Analysis, 2022

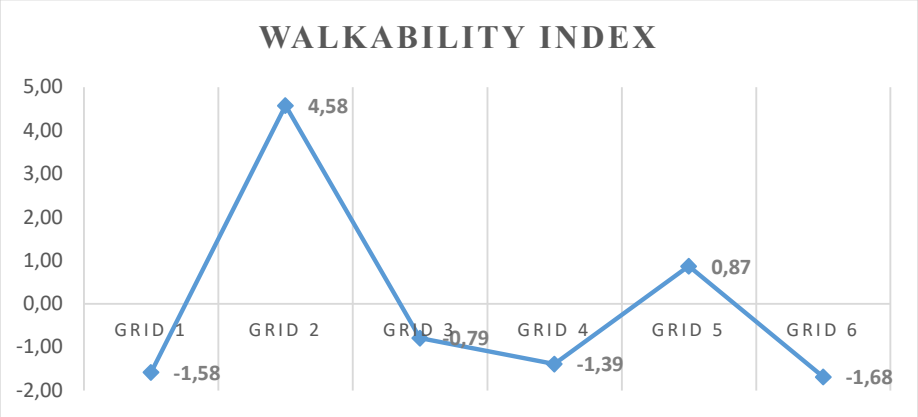

Figure 9. *Walkability Score in The CBD Area Jenderal Sudirman*
Source: Analysis, 2022

The picture above provides information that the average walkability score in the CBD area shows a variety. Interestingly, grid 2 (WAI 4,58) is the best walkable area since it has the highest connectivity score, provides good housing density, and is supported by a good floor area ratio. However, this grid also has weaknesses for pedestrians since the entropy component showed a negative index.

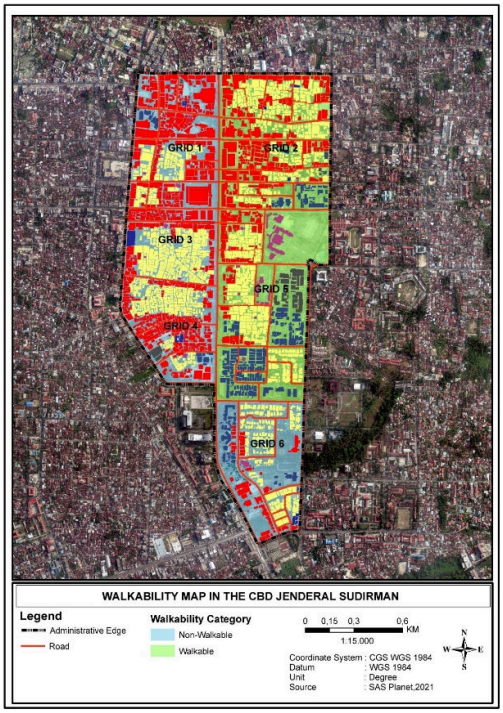

Figure 7. *Walkability Map*
Source: Analysis, 2022

3.2 Urban Form and Walking Choice

The measurement of walkability from the IPEN project represents that the CBD Jenderal Sudirman is not walkable since most grids in the CBD area are not walkable, or it is only two grids categorized as moderately walkable, there are grid 2 (WAI 4,57) and grid 5 (WAI 0,86). Besides, the previous analysis showed that walking decision is affected by urban form indicators (entropy, floor area ratio, housing density, perception, pedestrian facility distance to public transportation, and land use variety). Afterward, these urban form variables will be analyzed for walking trip categories (utilitarian, transit, and non-utilitarian). The description is as follows:

3.2.1 The Effect of Urban Form on Walking Choice for Utilitarian Purposes

In this research, the urban form variables consist of (1) entropy index, (2) floor area ratio, (3) household density, and (4) connectivity index. The chi-square analysis is used to see the effect of urban form on walking choice, whether for utilitarian, transit, or non-utilitarian purposes. Below table 8 shows the effect of urban form on walking for utilitarian categories:

Table 8. The Effect of urban form on walking choice for utilitarian purpose

Purp_walk 1	Coef	Std. Err	Z	P>{z}	{95% Conf.Interval	
Entropi_index	.2465042	.1254723	1.96	0.049	0.000583	.4924254
Floor_area_ratio	-1.628874	.7890847	-2.06	0.039	-3.175452	-.0822966
Household_ density	1.435713	.6907183	2.08	0.038	.08193	2.7894496
Connectivity_scale	-2.731128	.6986906	-3.91	0.623	-.7739188	.4632659
Constanta	-.6909685	.651799	-1.06	0.289	-1.968471	.586534

Source: Analysis, 2022

Table 8 above explains that the significant variable of urban form on walking choice for utilitarian purpose is entropy (P>{z} 0.049), floor area ratio (P>{z} 0.039), and household density (P>{z} 0.038).

On the one hand, most respondents said that land use variety (coef. 0.2465042) in the Jenderal Sudirman CBD is essential to ease pedestrian mobility without time wasted and attract more pedestrians to do diverse activities within one compact place on feet. In addition, several grids in the CBD Jenderal Sudirman (grid 4, grid 6) has a wide range of land uses, such as mall and department stores, government and private building, traditional market, recreation space, worker residential, and public facilities, which are pretty accessible for pedestrians.

On the other hand, floor area ratio (FAR) is also the crucial factor for utilitarian since it is affected by the total number of commercial activities. Most pedestrians in the CBD Jenderal Sudirman argued that they enjoyed visiting Grid 1, Grid 2, Grid 4 because it provides more trade and service activities than other grids. Moreover, the biggest trip attraction for pedestrians occurs in the afternoon now that many street culinarians are opened. Afterward, the housing density (P>{z} 0.038) also plays a vital role for utilitarian purposes. The more compact the housing location is (coef. 1.435713), the bigger chance they will decide to walk, the better the pedestrian facility in a housing area, the bigger opportunity to attract more people not to use private transportation.

In other words, density is the single most important factor associated with transit use (McIntosh et al., 2014; Merlin et al., 2021). As density increases, automobile ownership declines, and automobile travel decreases as measured by gasoline consumption or per capita vehicle miles of travel (VMT). In addition, many employees and workers who live in grid 2, grid 3, and grid 5 (>65%) said that they could save more money since the location of their workplace is near to their house.

3.2.2 The Effect of Urban Form on Walking Choice for Transit Purposes

Walking for transit purposes is defined as people who walk and use public or private transportation as a transit mode to reach their final destination (Guerra et al., 2018; Mcmullen, 2018) or vice versa. Below table 9 represents the effect of urban form on walking for transit purposes:

Table 9. *The Effect of Urban Form on Walking Choice for Transit Purpose*

Purp_walk 1	Coef	Std. Err	Z	P>{z}	{95% Conf.Interval	
Entropi_index	-.4852713	.2676366	-1,81	0.070	-1.00983	.0392868
Floor_area_ratio	1.141021	.3500898	3,26	0.071	.4548581	1.827185
Household_ density	-.7185431	.3817375	-1,88	0.060	-1.466735	.0296486
Connectivity_scale	-.4503391	.2178596	-2,07	0.039	-.877336	-.0233422
Constanta	-.641627	.4024125	1,59	0.111	-.147087	1.430341

Source: Analysis, 2021

Table 9 above provides information that the most significant variable which affects the transit walker is the connectivity index (P>{z} 0.039). Interestingly, transit pedestrians do not consider land use variety (entropy) as an essential element since they only pay attention to the pedestrian facility and accessibility to reach their destination. Also, another consideration for transit travelers is waiting time because it contributes to the travel time. In fact, some delays in Transmetro Pekanbaru (Public Buss) usually occur since there are many motorbikes and cars

usage, and there is also no specific lane for public buses. As a result, it causes delays in picking up passengers.

According to the current situation, most transit pedestrians said that they could easily walk in grid 2 (Con 98), grid 5 (Con 72), and grid 6 (Con 59) since they offer many connecting ways in or to reach the CBD Jenderal Sudirman. The more an area has intersections, the bigger chance to attract more pedestrians (Adolfsson et al., 2021; Crane, 1996; Walters, 2014). Unfortunately, the quality of each pedestrian facility is still not satisfactory enough, particularly in Grid 6, Grid 1, and Grid 4.

3.2.3 The Effect of Urban Form on Walking Choice for Non-Utilitarian Purposes

Generally, non-utilitarian groups are people who are not fully walking in their daily lives or only walking for a specific activity, such as going for sports, recreation, and entertaining only. Besides, they also prefer to use a private vehicle regularly to work or school. Below table 10 represents the effect of urban form on walking for non-transit purposes:

Table 10. *The Effect of Urban Form on Walking Choice for Non-Utilitarian Purpose*

Purp_walk 1	Coef	Std. Err	Z	P>{z}	{95% Conf.Interval	
Entropi_index	.2068412	.1366851	1.51	0.130	-.0610567	.4747391
Floor_area_ratio	-1.163959	.3675449	-3.17	0.052	-1.884334	-.4435846
Household_ density	.2890275	.388137	0.74	0.031	-.4717069	1.049762
Connectivity_scale	1.11486	.2658281	4.19	0.060	.5928468	1.634874
Constanta	-1.529301	.4295724	-3.56	0.000	-2.371248	-.6873547

Source: Analysis, 2021

Table 10 above illustrates that the significant variable which affects the non-utilitarian walker is household density (P>{z} 0.031). Interestingly, most non-utilitarian purposes come from unmanaged and dispersed urban housing, which surrounds the urban center area with limited public and social facilities, like in Grid 6 since this grid is occupied with elite people. This phenomenon is relatable with the argument of (Cao et al., 2006; Handy & Clifton, 2001; Holden & Norland, 2005) stated that non-utilitarian purpose usually happens in less compact residential housing. In addition, these findings are also suitable with (Handy & Clifton, 2001; Henk A Becker, 2011), who said that non-utilitarian activities begin with a luxurious settlement, non-well-organized housing, or old residential areas. Meanwhile, the ages of residential sites near CBD (Grid 2, Grid 3, Grid 4) in Jenderal Sudirman have been probably established for over 50 years, and it is not well-integrated with decent social and public facilities. The association between the pedestrian condition and housing density indicates that daily walking trips for non-utilitarian purposes are more likely to occur in non-well-organized residential

locations. Finally, household density is the only factor affecting non-utilitarian purposes in the CBD Jenderal Sudirman.

4. CONCLUSION AND RECOMENDATION

As sated above, this research aims to measure the effects of urban form on walking choice, where the walking is classified into utilitarian, transit and non-utilitarian trip. Afterwards, the measurement of walkability index is analysed by physical and environmental analysis. In the stage that follows, travel preference and moda choice are explained in order to measure the effect of urban form on walking choice for utilitarian, transit, and non-utilitarian purposes.

In terms of walkable evaluation, only two grids are classified as moderately walkable in the CBD area since the score for all indicators (entropy, floor area ratio, household density, and connectivity) is still low. Indeed, grid 2 (WAI 4,57) and grid 5 (WAI 0,86) is the walkable area in the CBD Jenderal Sudirman. Interestingly, walking for utilitarian and transit category prefers to visit grid 2 and grid 5 since they have a better pedestrian facility, land-use diversity, and connecting way, which ease pedestrian movement. In contrast, the negative and non-walkable areas accounted for grid 1, grid 3, grid 4, and grid 6 now that they did not meet the requirements or even negative scores. However, motorized transportation is still the most favorable transportation in the CBD area, where only 36,6% of respondents accounted for walking mode, and 63,4% contributed to non-walking choice as their daily mobile.

In a broad sense, urban form variable (entropy, floor area ratio, household density, connectivity) significantly impacts walking choice, whether for utilitarian, transit, or non-utilitarian purposes. Based on the chi-square analysis, the urban form variables which have a significant impact on walking choice for utilitarian purposes are entropy (P>{z} 0.049), floor area ratio (P>{z} 0.039), and household density (P>{z} 0.038). Besides, the level of urban compactness in grid 2 and grid 5 contributes to the utilitarian pedestrian in as much as the accessibility and integrity of various land use, good pedestrian connectivity, and centralized commercial activity. Meanwhile, walking for transit purposes is usually conducted by people who do not have a private vehicle, and they alternatively walk and ride public transportation (TransMetro Pekanbaru) to reach their final destination. Interestingly, the transit walkers are only affected by the connectivity variable (P>{z} 0.039).

Surprisingly, most non-utilitarian walkers came from disorganized and agglomerated housing with low basic services and pedestrian facilities. According to the study, dwellers who live in grid 2, grid 5, and grid 6 have lived for over 40 years. Also, many informal residential like urban kampung communities routinely walk as their main activity. Ironically, people who

live in well-organized housing with good pedestrian facilities indicate less interest in walking since they rely upon private vehicles, or they only walk for a specific activity, such as going for sports, seeing car-free day, and looking for street food carnival on the weekend in the CBD site.

Some limitations are bound to the method of calculating the urban form and walkability index. The first and most important one is that all the components are standardised, which means that they are relative. In other words, the value of the index strictly depends on the parameters of the group of developments selected for comparison. In our research, the group included only four developments, three of which are characterised by the deliberate shaping of urban form according to the walkability concept. Therefore, final values of the walkability index cannot be reliable for assessing the walkability of the entire city in Pekanbaru. The next research probably could use qualitative method to explore more about urban form variables and walkability index since travel behavior, travel decision making process and travel perception is must be explained more to determine the urban form stages.

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