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Spatial Characteristics Visualization of Transfer Point Infrastructure

Melawaty Agustien[1,*], Muhamad Rizki[2], Agus Lestari Yuono[1], Marice Agustini[3], Indra Satriadi[4]

[1] Department of Civil Engineering, Faculty of Engineering, Sriwijaya University, Kota Palembang, Sumatera Selatan 30128, Indonesia
[2] University of Natural Resources and Life Sciences Vienna, Gregor-Mendel-Straße 33, 1180 Wien, Austria
[3] Department of Civil Engineering, Faculty of Engineering, Muhammadiyah University of Palembang, Kota Palembang, Sumatera Selatan 30263, Indonesia
[4] Department of Informatics Management, Sriwijaya State Polytechnic, Kota Palembang, Sumatera Selatan 30128, Indonesia

ABSTRACT

The government's efforts to increase public transport users in Palembang by providing public transport such as LRT, Teman Bus and angkot feeder LRT Musi Emas. The previous research shows that there are still deficiencies in public transport services. The condition of physical integration between public transport, such as no bus stop, inadequate sidewalk facilities and even in some locations they are not available, no crossing bridges, no lighting, no information on routes, schedules and several other things. Based on these conditions, this research will study physical integration between public transport modes by visualizing the spatial characteristics of transit point facilities in Palembang City. The method used for visualization is a mapping model using the GIS 10.8 application. The results of this research show that the districts with the most transfer points in Palembang are Ilir Timur I and Alang-Alang Lebar which have LRT stations, bus stops and river mode infrastructures. The results of this research can be used as a reference for improving public transport physical integration in Palembang in areas served by public transport. The visualization results of transfer point users in Palembang have shown that Ilir Barat I and Sukarame Districts have the highest number of users of transfer points infrastructure LRT station. Based on this research, it is known that the availability of transfer points infrastructure is not necessarily accompanied by a high number of public transport users in one sub-district when compared to other sub-districts. This is partly due to inadequate condition of physical integration between public transport.

Keywords:
Public transport; physical integration; mapping model; transfer points

1. Introduction

Infrastructure is characterized as physical infrastructure that provides social and economic transportation, buildings, irrigation, drainage and other public facilities that are indispensable for meeting human needs [1]. Although infrastructure is often associated with environmental systems, in economic and social systems, the provision of infrastructure affects existing urban social and economic systems, therefore infrastructure must be recognized as a basis for decision-making [2]. Some previous research has looked at several factors that cause inequality in Indonesia. One of them

* *Corresponding author.*
E-mail address: melawatyagustien@ft.unsri.ac.id

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is the difference in the distribution of infrastructure development between existing regions [3]. Equal distribution of transportation infrastructure development is important because this infrastructure influences the development of a region [4]. Completion of the right infrastructure is an important part of the growth of a region because it is the key to improving the economy [5,6]. In this research, the distribution of transfer points infrastructure locations in the city will be observed to find out how effective the infrastructure is in increasing public transport users in Palembang City. Increasing public transport users will have an impact on improving the socio-economic conditions of the people of Palembang City

Movement at a location needs to be supported by adequate transportation infrastructure [7]. This movement starts from the origin to the destination at a certain place and within a certain period. Based on the concept of motion, it is possible to determine which areas experience movement in high, medium and low magnitudes [8,9]. The concept of motion is divided into two, namely non-spatial motion and spatial motion [10]. Non-spatial movement is caused by the purpose of the trip related to economics, society, culture, education and religion. Spatial movement is a movement that is always associated with the relationship pattern between the spatial distribution of travel and the distribution of land uses in an area [11].

Transportation infrastructure in Palembang City consists of roads, rail, river, sea and air modes. For people's trips within the city of Palembang, it can be served by various modes of public transportation consisting of highway, rail and river modes. However, public transport users in the city of Palembang are still very low, private transport users in the city of Palembang reach 95.1%, while public transport users only reach 4.9% [12]. This shows the importance of improving public transport services to increase users. Based on the need for service improvement, it is necessary to know the spatial characteristics of the modal shift infrastructure in Palembang City using a Geographic Information System (GIS). To find out the distribution of the availability of modal shift infrastructure in the sub-districts of Palembang City, so that later it can become a reference for the government in providing modal shift infrastructure in areas that do not yet have this infrastructure. It can be seen from the users of the modal shift infrastructure in the district whether there are many users or not. Equal distribution of transfer points infrastructure plays an important role in efforts to support intermodal integration in a city [13].

A Geographic Information System (GIS) is a series of computer systems for capturing, storing, checking and displaying data related to positions on the earth's surface [14]. With its advantages, namely being able to explain events, predict results and plan strategies. GIS (Geographical Information System) or geographic and mapping-based information system is a management tool in the form of computer-assisted information related to the mapping system and analysis of everything, as well as events that occur on this earth [15-17]. It is necessary to use a geographic information system in this study, because the development of information technology has grown rapidly in recent decades, development based on information technology has become a necessity as a management tool [18].

The data to be processed in the GIS is data from a profiling study on LRT passengers in South Sumatera 2022 conducted by the South Sumatra Light Railroad Operations Centre and Sriwijaya University [19]. Infrastructure data from Transportation Information System for Palembang City in 2022 by the Development Planning Agency at the Sub-National Level of Palembang City [20] and an evaluation study on intermodal transfer points for Palembang City in 2022 by Palembang City transportation department [21]. In addition to these data, supporting spatial data is also used, namely administrative maps of sub-districts in Palembang City in the form of digital maps. The GIS visualization process begins by collecting data with a home interview survey conducted by the South Sumatra Light Rail operation centre in 2022. Based on the results survey, users of LRT station

infrastructure were 62.8%, bus stop users were 20.0%, bus stop angkot feeder users were 15.7% and wharf users were 1.4%. Then the distribution of modal shift infrastructure, shows that Palembang City has 18 sub-districts with 11 LRT stations, 235 bus stops, 106 bus stops for angkot feeder and 38 piers. Then input the administrative map of Palembang City in the form of SHP (shapefile) into the GIS and add infrastructure distribution points and graphs of Palembang city transportation infrastructure users in each District.

The gap between this research and other research that is significant in this research is presenting information visually in the form of a map and graphs. Where in general information on the condition of transportation infrastructure and its users is presented in the form of tables, graphs and diagrams. The expected results of this research are visualization of the distribution of modal shift infrastructure and users of modal shift infrastructure in the City of Palembang so that transportation facilities and services can be provided according to the needs of the activities of the people in Palembang City.

Based on the situation that has been described, the objectives of this research are to identify the distribution of transfer points infrastructure locations in Palembang City and produce and analyse visualization of the Geographic Information System (GIS) distribution of locations and users of the infrastructure.

2. Methodology

2.1 Literature Studies

A literature study is the first step in studying a subject that is used as supporting data and references in conducting research. This literature study is intended to obtain a clearer picture of the subject matter studied in the research. Literature studies are also useful for assisting the stages of implementation, analysing research results and providing solutions to problems that occur during research. The use of references in research is useful as a reference based on books, journals, proceedings, regulations or standards and previous research.

2.1.1 Transportation

Transportation consists of vehicles, infrastructure and service systems that enable movement throughout the region. resulting in population mobility and the movement of goods and services [10]. There are two types of community travel options, namely using transportation (driving) or not using transportation (walking). Transportation is defined as the movement of goods and people from a point of origin to a destination. So, in this activity, there are three things, namely the availability of goods to be transported, the availability of transportation facilities and the existence of roads that can be traversed. The process of moving from the point of origin, namely where the transportation activity begins and to the destination where the activity ends. Therefore, freight and passenger transportation are an industry that can support economic activities and provide services for economic development.

Community transportation infrastructure needs such as roads, ports, stations, airports and others. is an indicator of financial need (investment). The community's connection with the infrastructure of the transportation system is marked by the occurrence of travel between the two places because the people's needs to carry out their daily lives are separated in terms of space from origin to destination [11]. By allocating land use in certain areas to the functions of the parties in each area, from the local to the national level, people can travel between two places of departure and arrival.

The transportation system has the basic concept of urban movement, which is the basic principle and starting point for research in the field of transportation. This concept is divided into two parts, namely:

i. the characteristics of non-spatial motion or no spatial boundaries in a city, for example, related to why people travel and what mode of transportation is used.
ii. moving in space or with spatial boundaries within the city, including patterns of cultivation, patterns of movement of people and patterns of movement of goods. In transportation, motion is divided into two types, namely non-spatial motion and spatial movement

Infrastructure is a physical system that provides transportation, irrigation, drainage, buildings and other public facilities such as electricity, telecommunications and drinking water, which are necessary to meet basic human needs, both socially and economically [8]. The infrastructure system is the main driver of the social system and economic system in people's lives.

2.1.2 System information geographic (GIS)

According to Nugroho [14], a Geographic Information System (GIS) is a computer-based information system that is used to manage and store data in the form of geographic information. GIS is a science in the field of technology that combines geographic features with non-spatial data/attributes to map, analyse and evaluate real-world problems involving spatial or spatial.

Based on its initial design, the main function of GIS is to perform spatial data analysis. From a geographic data processing point of view, GIS is not a new invention. Geographical data processing has long been carried out by various fields of science, what distinguishes it from the old processing is only the use of digital data. The basic functions in GIS are as follows:

i. Data acquisition and initial process include digitization, editing, topology development, data format conversion, attribute assignment, etc.
ii. Database management includes data archiving, multilevel modelling, attribute search network modelling, etc.
iii. Spatial measurement and analysis include: measurement operations, buffer zone analysis, overlay, etc.
iv. Display of graphics and visualization includes: scale transformation, generalization, topographic maps, statistical maps, perspective view

2.1.3 Spatial data

Spatial data in GIS is the main data component that cannot be separated which consists of relative geographic information about the earth and its features. There are two parts important managed data in GIS consist of:

i. Spatial Data: Contains location information related to a coordinate, both geographical coordinates (latitude and longitude) and XYZ coordinates, including information regarding datum and projection.
ii. Attribute Data/Tabular (*Non* spatial): Filled with descriptive or non-spatial information, which includes information on area, postal code, street name, type of vegetation, value

or numbers and so on. In Spatial data storage techniques distinguished into 2 namely raster data and vector data.

- Raster Data: It consists of grid cells identified by rows and columns. The entire geographic area is divided into several groups of grid cells or commonly called pixels (picture *elements)*, which represent an image. The images are from satellites, aerial photographs, scan results and others.

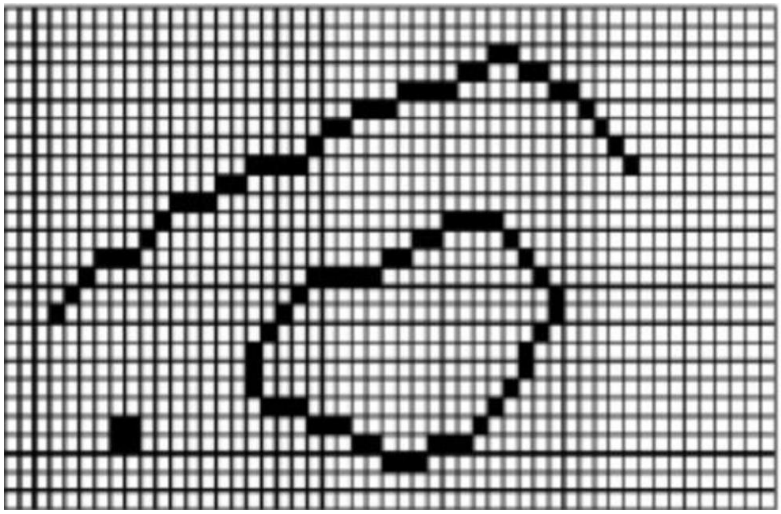

Fig. 1. Raster data

- Vector Data: Is a representation of the shape of the earth into a collection of *points* (*nodes* that have labels), lines (*arcs/lines*), areas (*polygons*) (areas bounded by lines that start and end at the same point) and nodes (intersection points between two lines).

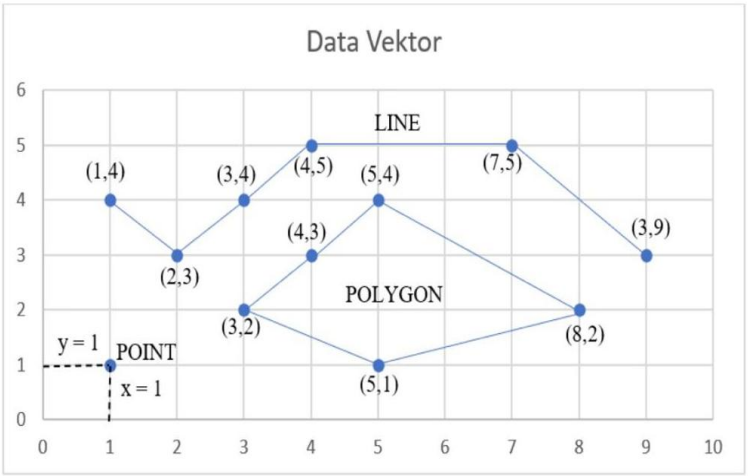

Fig. 2. Vector data

2.1.4 Creating ArcMap

ArcMap is a working page in *ArcGIS* 10.8, as well as the main application for GIS processing and computer mapping. *ArcMap* has the ability for visualization, building spatial databases, editing, map design, analysis, creating 3D maps and more. The following picture shows the work page on ArcMap, where all spatial data processing activities are carried out.

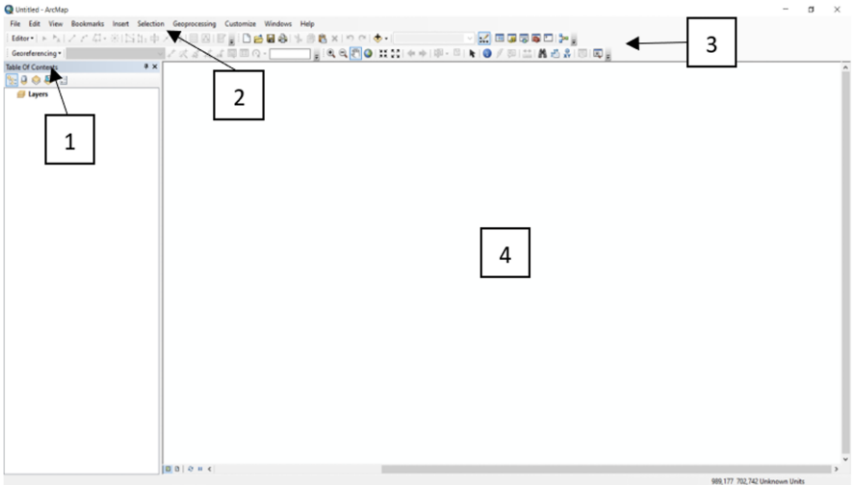

Fig. 3. Display *ArcMap*

i. Table of Content (TOC): TOC is a list or table of contents contained in the data view. TOC contains layers that represent data in the *data view*.
ii. Bar Menu: A collection of menus on ArcMap.
iii. Toolbar: Contains tools that are useful when we do spatial data processing. To activate the toolbar, select the Customize > Toolbars menu, then select the tools to display on the toolbars.
iv. Data Views: Displays spatial data input on ArcMap.

2.2 Defining Problems and Research Objectives

The formulation of the problem and research objectives is a very important activity in researching because the formulation of the problem is the driving force for research to be carried out and functions for research, while the research objectives are answers to questions posed in the research development process.

2.3 Data Collection

This research requires data in the form of primary and secondary data obtained from certain parties/agencies. The following are data that are used in this research.

i. Palembang City administrative map
ii. Identification of transfer point infrastructure location using Google tracking
iii. Spread location of transfer point infrastructure in Palembang's subdistricts
iv. Number of user transfer points in Palembang; 's subdistricts

2.4 Data Processing

Processing the data is the next step after the data is collected. In this step, the data was performed in visualization, namely:

i. Distribution of transfer point infrastructure locations in Palembang's subdistricts.
ii. Identification number of modal shift infrastructure users.

The ArcGIS software 10.8 is used to create and edit t a map legend, add cardinal directions and add a scale bar and scale text.

2.5 Analysis

The analysis obtained is the characteristics of the distribution of locations and the number of modal shift infrastructure as well as users of modal shift infrastructure in the city of Palembang in the form of earth maps and information tables.

3. Results

3.1 Data Presentation

The data presented is secondary data. The secondary data presented is data on the distribution of modal shift infrastructure from an evaluation study of intermodal transfer points for the City of Palembang, the study of the Transportation Information System and the results of the LRT passenger profiling study in 2022. This study aims to determine the distribution of locations and the number of users of modal shift infrastructure in the city of Palembang. The survey was carried out by asking the questions in the questionnaire by the surveyor *and* the questionnaire was also filled in by *the* surveyor based on the answers from the people being interviewed. The survey was conducted in 2022. Table 1 presents the total distribution of transfer point infrastructures. The following is a recapitulation of the number of transfer points infrastructure data used for data processing.

Table 1
Number and distribution of transfer points infrastructure locations

District/zone	Number of LRT Stations	Number of Bus Stops	Number of Angkot Feeders Stops	Number of River mode infrastructure	Amount
Ilir Barat II	0	0	0	1	1
Gandus	0	0	0	1	1
Sebrang Ulu I	2	0	0	1	3
Kertapati	0	0	0	0	0
Jakabaring	1	0	0	1	2
Sebrang Ulu II	0	0	0	2	2
Plaju	0	0	0	0	0
Ilir Barat I	2	40	0	0	42
Bukit Kecil	0	0	0	0	0
Ilir Timur I	4	26	0	2	32
Kemuning	1	0	0	0	1
Ilir Timur II	0	28	0	0	28
Kalidoni	0	34	0	0	34
Ilir Timur III	0	0	0	0	0
Sako	0	80	28	0	108
Jakabaring	0	0	12	0	12
Sukarame	0	27	44	0	71
Alang-Alang Lebar	1	0	22	30	53
Amount	11	235	106	38	390

The data presented in Table 1 shows the number and distribution of modal shift infrastructure in Palembang City which has 390 infrastructure located in 18 sub-districts, the largest number of LRT station infrastructure in Ilir Timur I District with 4 stations, the largest number of bus stop infrastructure in Sako District with 80 bus stops, the largest number of angkot *feeder stops* were in

Sukarame District with 44 bus stops, while the number of dock infrastructure was in Alang-alang Lebar District with 30 piers.

The number of users of modal shift infrastructure data in Palembang City was obtained from the results of the 2022 LRT passenger profiling study. Table 2 presents the number of modal shift infrastructure users. The following is a recapitulation of survey data used for data processing.

Table 1
Number of transfer points infrastructure users

Subdistrict	LRT Users	Bus Users	Angkot Feeder Users	River Mode Users	Amount
Ilir Barat II	0	0	0	0	0
Gandus	0	0	0	0	0
Sebrang Ulu I	2	0	0	0	2
Kertapati	0	0	0	0	0
Jakabaring	1	1	0	0	2
Sebrang Ulu II	2	0	0	1	3
Plaju	0	0	0	0	0
Ilir Barat I	20	1	2	0	23
Bukit Kecil	1	1	0	0	2
Ilir Timur I	5	1	0	0	6
Kemuning	1	0	0	0	1
Ilir Timur II	0	0	0	0	0
Kalidoni	0	0	0	0	0
Ilir Timur III	0	0	0	0	0
Sako	0	1	0	0	1
Jakabaring	0	0	2	0	2
Sukarami	12	8	7	0	27
Alang-Alang Lebar	0	1	0	0	1
Amount	44	14	11	1	70

The data presented in Table 2 shows the number of modal shift infrastructure users in Palembang City. The table above shows that the largest number of LRT passengers were in Ilir Barat I Subdistrict as many as 20 people, the largest number of bus passengers in Sukarame Subdistrict were 8 people, the largest number of angkot feeder was in Sukarame Subdistrict as many as 7 people, the largest number of boat passengers were in Sebrang Ulu II Subdistrict as much as 1 person. The distribution of infrastructure users in Palembang City was explained in the percentage of each sample transfer point infrastructure users. Based on the calculation result, 45% of Stasiun LRT users are in Ilir Barat I District, 57% of bus stop users in Sukarame and 64% of angkot feeder stops users are also in Sukarame District, while all the infrastructure of river mode users are in Sebrang Ulu II District.

3.2 Data Processing

In this data processing sub-chapter will explain how to process data on the number of transfer points infrastructure location distributions in Table 1, to be visualized into ArcGIS which will produce output in the form of a modal shift infrastructure location map layout in Palembang City. Description of the pictures as follows:

i. Spread location of mode transfer points infrastructure: The results of the visualization of the distribution of all transfer points infrastructure are obtained as follows (Figure 4). The results of the visualization above are the distribution of infrastructure locations throughout the Districts of Palembang City. According to the map above, it can be seen

that the largest distribution of LRT station infrastructure is in Ilir Timur I District, the largest distribution of bus stop infrastructure is in Sako District, the largest distribution of angkot feeder bus stop *infrastructure* is in Sukarame District, while the largest distribution of dock infrastructure is in Alang-alang Lebar District.

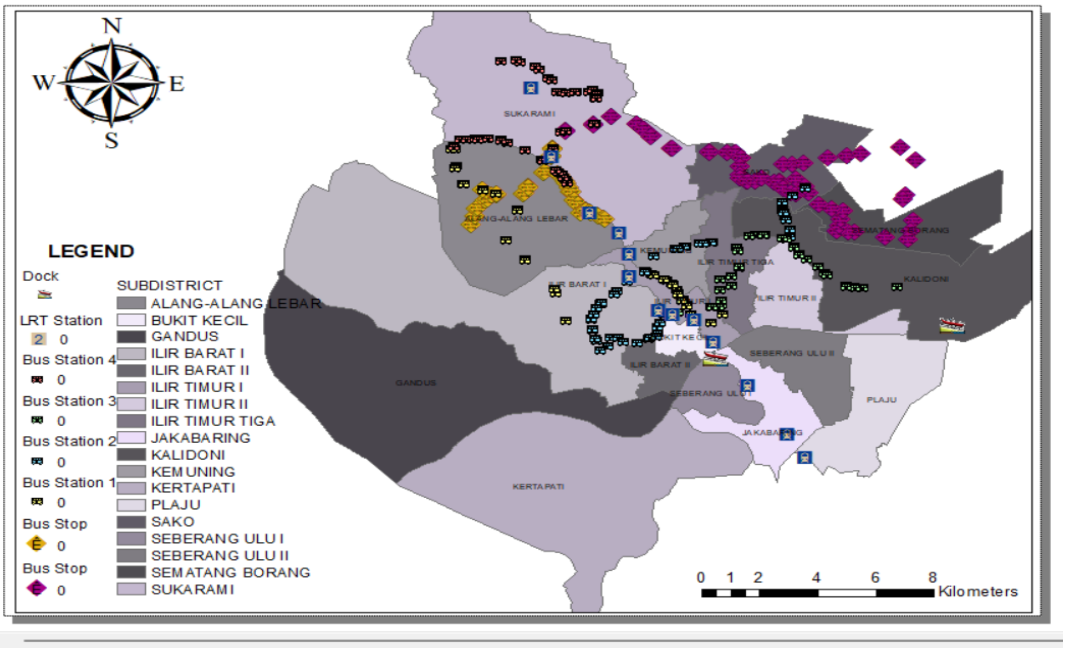

Fig. 4. Distribution of modal shift infrastructure locations in Palembang City

ii. Spread location of LRT station infrastructure: The results of the visualization of the distribution of LRT station infrastructure are as follows (Figure 5). The figure above shows the largest distribution of LRT station infrastructure locations in Ilir Timur I District with 4 stations. The least distribution of LRT station infrastructure locations is in the Jakabaring, Kemuning and Alang-alang Lebar Districts consisting of 1 station.

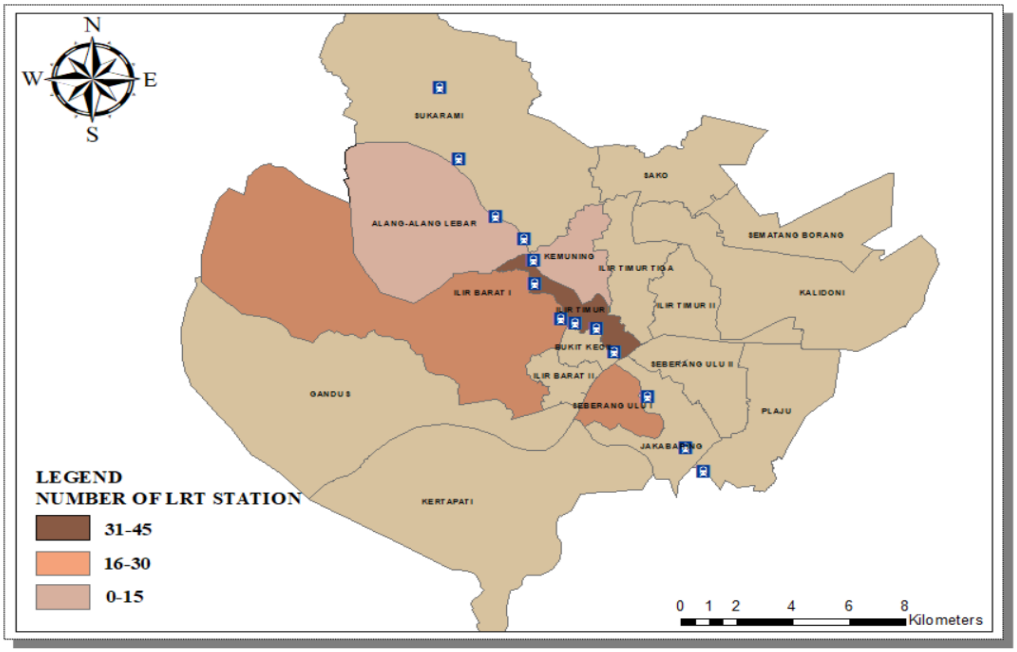

Fig. 5. Distribution of LRT station infrastructure locations in Palembang City

iii. Spread location of bus stop infrastructure: The results of the visualization of the distribution of bus stop infrastructure are obtained as follows (Figure 6). The figure above shows the largest number of bus stop infrastructure locations in Sako District, with 80 bus stops. The least distribution of bus stop infrastructure is in the District of Ilir Timur I with 26 stations.

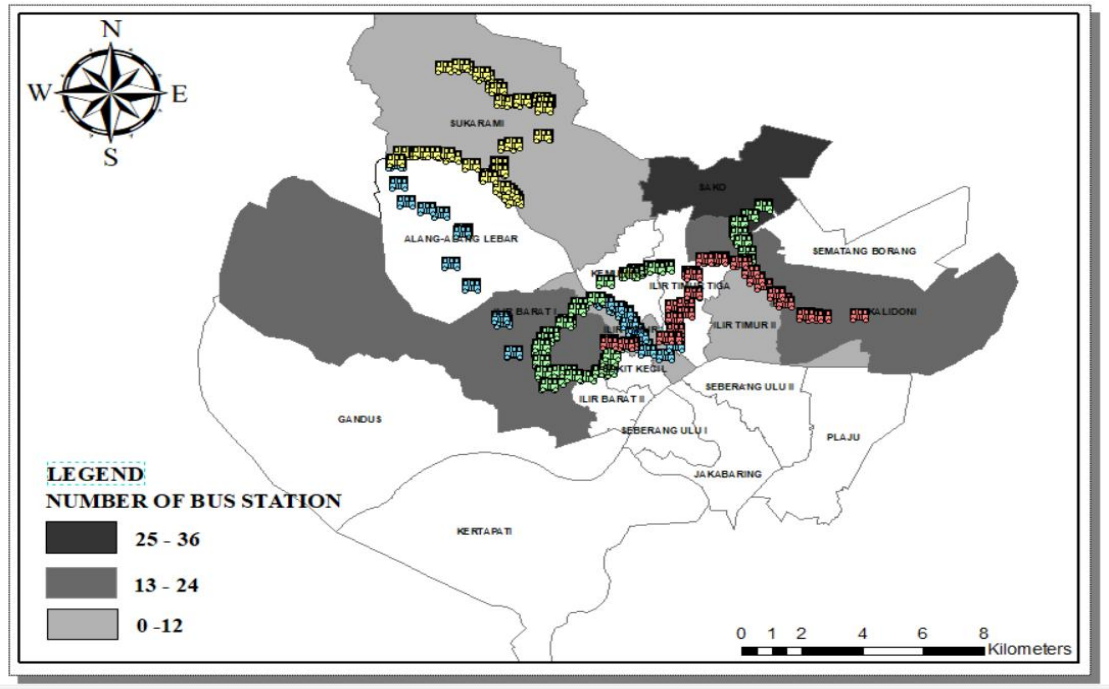

Fig. 6. Distribution of the location of the bus stop infrastructure in Palembang City

iv. Spread location of Angkot feeder bus stop infrastructure: The results of the visualization of the distribution of the angkot *feeder* stop infrastructure are obtained as follows (Figure 7). The figure above shows the largest number distribution of Angkot feeder stop infrastructure locations in Sukarame District, with 44 bus stops. The least number of distributions of angkot feeder stops infrastructure is in Sematang Borang District.

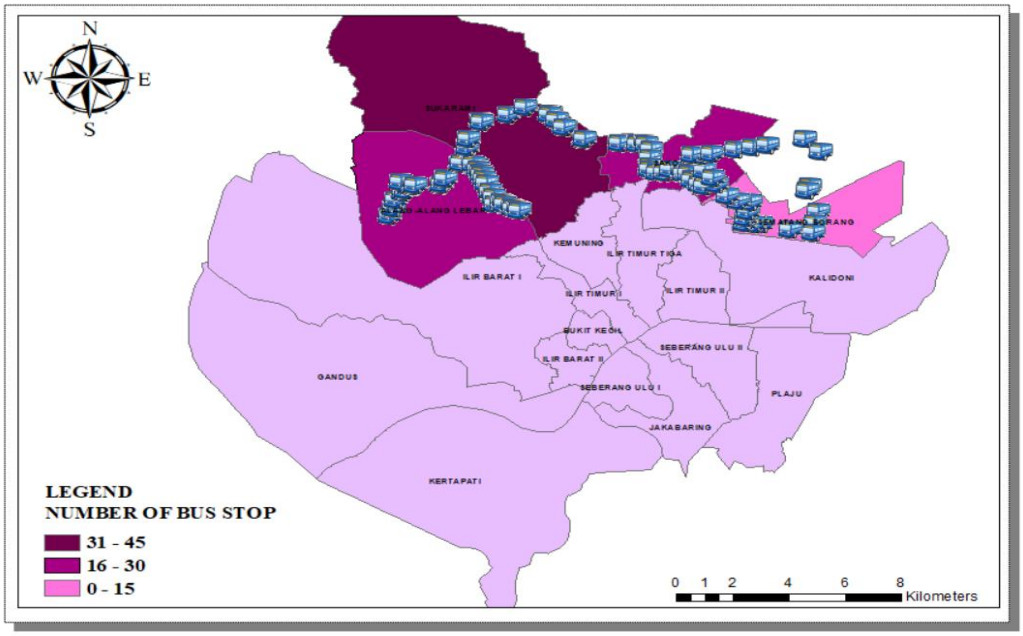

Fig. 7. Distribution of bus stop feeder infrastructure locations in Palembang City

v. Spread location of river mode infrastructure: The results of the visualization of the distribution of river mode infrastructure are obtained as follows (Figure 8). The figure above shows the largest distribution of dock infrastructure locations in Alang-alang Lebar District, with 30 piers. The least number of distributions of pier infrastructure locations is in Ilir Barat II, Gandus, Sebrang Ulu I and Jakabaring Districts.

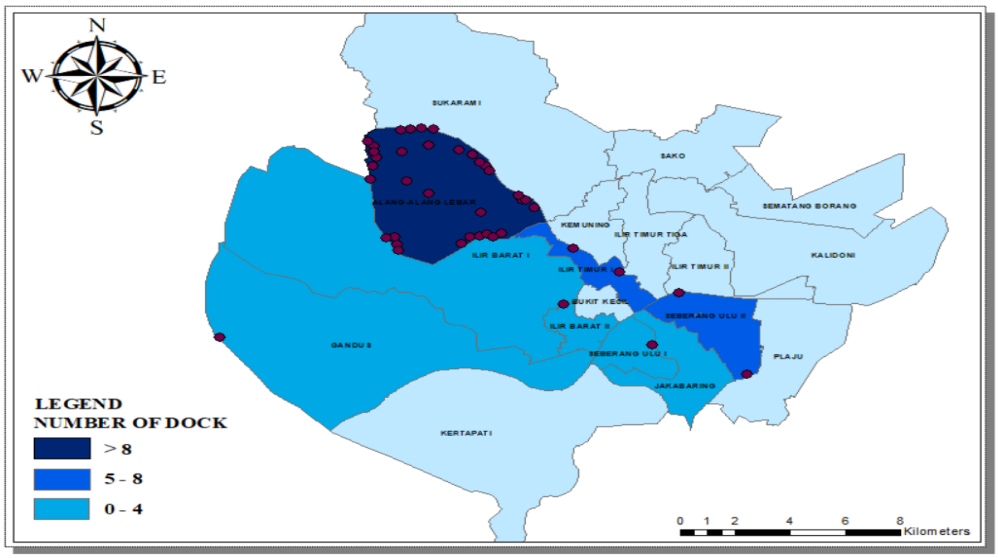

Fig. 8. Distribution of dock infrastructure locations in Palembang City

vi. Spread location of transfer points infrastructure users: The results of the visualization of transfer points infrastructure users in the City of Palembang are shown in Figure 9.

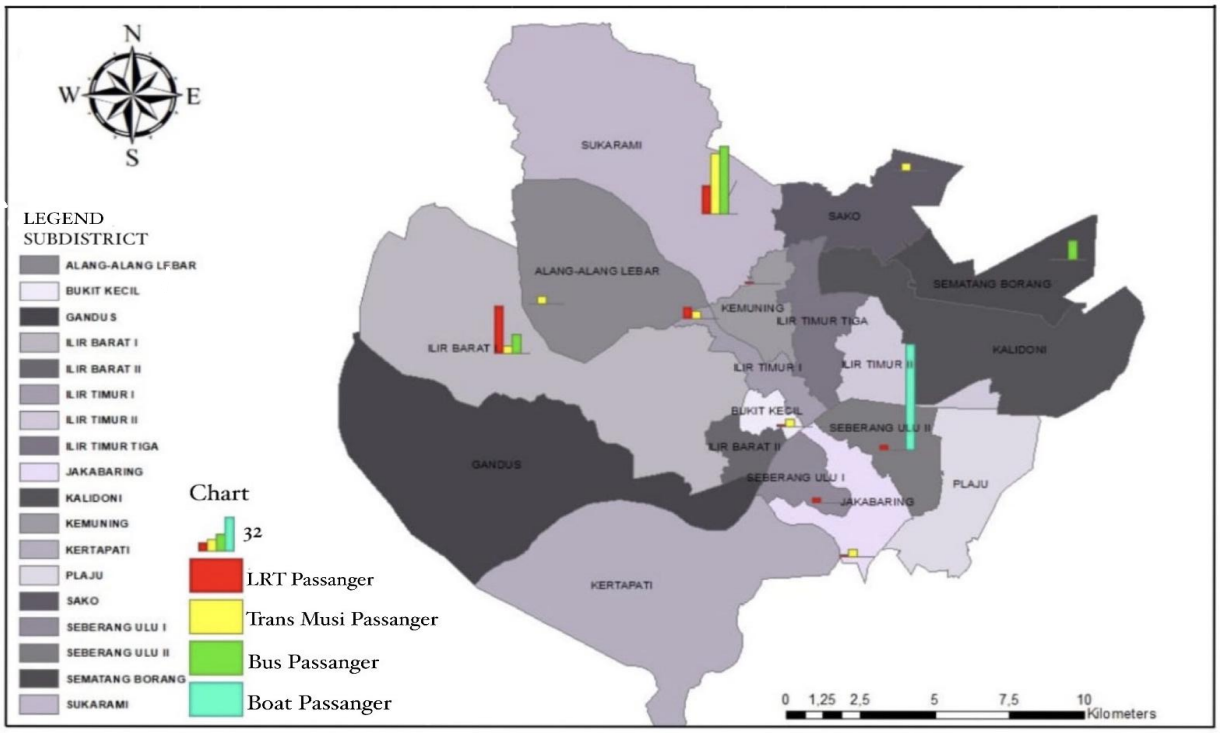

Fig. 9. Distribution user's transfer point infrastructure

Based on the Figure 9 the distribution of mode transfer points infrastructure users in Palembang City obtains the following results:

i. The highest number of LRT passengers were in Ilir barat 1 sub-district, with a total of 20 people (45%) from the total sample of LRT users and the fewest in Jakabaring, Bukit Kecil and Kemuning sub-districts with 1 person (2%) from the total sample of LRT users.
ii. Most of the bus passengers were in the Sukarame District with a total of 8 people (57%) from the total sample of bus users and the fewest were in the Jakabaring, Ilir Barat I, Bukit Kecil, Ilir Timur I, Sako and Alang-Alang Lebar subdistricts with a total of 1 person (7%) of the total sample of bus users.
iii. Angkot *feeder* passengers were in Sukarame District, 7 people (64%) of the total sample angkot feeder users and the fewest were in Ilir Barat I and Sematang Borang Subdistrict, 2 people (18%) of the total sample angkot feeder users.
iv. Of all the boat passenger sub-districts, 1 person (100%) is in the Sukarame sub-district from the total sample of boat users.
v. Based on the discussion above, it can be identified that most infrastructure users are LRT passengers with as many as 20 people and most users are in Ilir Barat I District. The least infrastructure user is boat passengers, there is 1 person in Sebrang Ulu II District.

3.3 Analysis of Data Processing Results

This sub-chapter will discuss the results of the analysis of the distribution of location and users of transfer points infrastructure. From the analysis of the distribution of transfer points infrastructure locations in Palembang City, the sub-districts with LRT stations infrastructure are Sebrang Ulu I, Jakabaring, Ilir Barat I, Ilir Timur I, Kemuning and Alang-alang Lebar Districts. Bus stop infrastructure is in Ilir Barat I, Ilir Timur I, Ilir Timur II, Kalidoni, Sako and Sukarame Districts. The angkot feeder bus

stop infrastructure is in the sub-districts of Sako, Sematang Borang, Sukarame and Alang-alang Lebar. The wharf infrastructure is located in the sub-districts of Ilir Barat I, Gandus, Sebrang Ulu I, Jakabaring, Sebrang Ulu II, Ilir Timur I and Alang-alang Lebar. Based on the survey results, the most numerous transfer point infrastructure among the other sub-districts is the Ilir Timur I sub-district, which has the infrastructure of LRT stations, bus stops and wharves. Then the Alang-alang Lebar District which has an LRT station, bus stop and a wharf. Of all the sub-districts in Palembang City where there is no transfer point infrastructure, these are Kertapati, Plaju, Bukit Kecil and Ilir Timur III sub-districts.

The results of the analysis of the distribution of transfer points infrastructure users in Palembang City, based on the research results that there are infrastructure and users of transportation infrastructure in Ilir Barat I District with 40 bus stops while there is 1 bus stop user. Ilir Timur I District has 26 bus stops, while 1 person is using the bus stop. Ilir Timur II Subdistrict has 28 bus stops, Kalidoni Subdistrict has 34 bus stops, Sako Subdistrict has 80 bus stops and Sukarame District has 27 bus stops, but there are no infrastructure users. Sako District has 28 angkot feeder stops but there are no infrastructure users. Sematang Borang sub-district has 12 angkot feeder stops while there are 2 angkot *feeder* users. Sukarame District has 44 angkot *feeder* bus stop while there are 7 angkot feeder users. Alang-Alang Lebar District has 22 angkot feeder bus stops but there are no infrastructure users. Alang-Alang Lebar District has 30 piers but there are no infrastructure users.

Based on the survey results, there are no public transport users, even though the sub-district has a transfer point infrastructure. Located in the Districts of Ilir Barat I, Gandus, Sebrang Ulu I and Jakabaring, it has 1 pier. Ilir Timur, I has 2 piers, Ilir Timur II has 28 hate buses, Kalidoni has 34 bus stops, Sako has 28 angkot feeder stops, Alang-alang Lebar has 1 LRT station, 22 angkot feeder stops and 30 piers.

4. Conclusions

The research concluded that Palembang City's distribution of transfer point infrastructure is notably uneven across its districts. Currently, there are 11 LRT stations, 235 bus stops, 106 angkot feeder stops and 38 piers, with specific areas showing a higher concentration. For instance, Ilir Timur I District has the most LRT stations, with four, while Sako District contains the largest number of angkot feeder stops (80), Sukarame District leads with 44 bus stops and Alang-alang Lebar District has the highest number of piers (30). Some sub-districts, such as Kertapati, Plaju, Bukit Kecil and Ilir Timur III, lack transfer point infrastructure altogether, highlighting the uneven spread across the city.

A Geographic Information System (GIS) was utilized to map these distributions and visualize the transfer point locations in each district. The GIS results effectively display the geographic spread and density of these facilities, helping identify infrastructure gaps in certain areas of Palembang. Furthermore, the GIS also mapped the usage of modal shift infrastructure, providing insight into where the highest concentrations of users are located.

Interestingly, the highest usage of modal shift infrastructure is observed in Ilir Barat I and Sukarame, primarily at LRT stations. However, the data indicates that infrastructure availability does not always align with high user numbers across all sub-districts, suggesting that additional factors, such as intermodal integration, influence usage. Improved intermodal connectivity could help optimize the utilization of public transportation facilities across Palembang, as better-connected systems may encourage higher ridership, especially in areas currently underserved by transfer point infrastructure.

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