Empirical analysis of the relationship between ring road development and land use transformation in Salatiga City

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Abstract. As many as 99% of national logistics transportation using land routes. To accommodate the need for logistics, the development of ring road is an efficient solution, especially to prevent the distortion of activities within the city. Likewise with Salatiga City, the construction of Salatiga’s South Ring Road aims to reduce congestion on the main road in the city center. Of course, the existence of the ring road is affecting land use change in Salatiga City, especially in areas passed by the ring road. Therefore, the research question is how the relationship between the ring road and land use transformation in Salatiga City. While the purpose of this research is to identify the form of relationship between the ring road and land use transformation in Salatiga City.

Keywords: ring road, land use transformation, relationship

1. Introduction

99% of logistics transportation in Indonesia urban uses road network [¹]. In addition, national economic mobility also depends on the urban road network. The urban road network not only accommodate logistics route, but also accommodate city activities. Consequently, that along with the development of the city, urban activities and logistic transport activities cause new problems in the city, congestion. Therefore, to accommodate these needs, ring roads is an alternative way for logistics routes in urban areas [²]. The ring road, which is generally built on the outskirts of the city, certainly causes the surrounding land use to develop, based on theory by Babcock (1960) [³]. The Sxial Babcock Theory states that the transport axis is the main factor that influences mobility, especially the relationship between Central Bussiness District (CBD) and its outer area. Zones along this transportation axis will growth faster than other zones.

As one of the cities passed by the main logistics route of Java Island, Salatiga City also uses ring roads as an alternative circulation of the city, which was built on the southern lane of the city. The southern ring road began operating in 2012, which aims to break congestion on the Salatiga City arterial road. In addition, arterial roads in the city of Salatiga also do not meet the capacity as the main logistics line, due to the increasing activity of the city community. Over time, transportation activities on the southern ring road are increasing. This causes increased activity around the ring road. The activities of the ring road and land use transformation are certainly interrelated.

Relationship between the axis of transportation and changes in land use can be seen in the phenomena around us, that land use changes depending on the activity of the road that passes through
it. Likewise vice versa, road activities will adjust the land use around it \[4\]. But, the road does not fully affect the land use change, there are external factors that influence, such as policy, topography, and constellation with other regions \[5\]. Therefore, this paper will discuss the relationship of ring road and the transformation of surrounding land use.

2. Method

2.1. Study area
This research was conducted in Salatiga City, which was located in Central Java Province. Salatiga is a small city with a population of 186,420 people. Morphologically, it is located in the foot basin area of Mount Merbabu, and is located between small mountains, such as Gajah Mungkur, Telomoyo, and Payung Rong \[6\]. Salatiga City is passed by transportation routes that have quite high activity, because the main road in the City of Salatiga connects the National Activity Center (PKN) and the Regional Activity Center (PKW). The density of the main road activity is the background of the Central Java Provincial Government to build the South Ring Road (JLS) Salatiga in the interests of logistics transportation. The road network system in the City of Salatiga is also passed by the Semarang-Solo Toll Road, especially in Bugel Village, Kauman Kidul Village, and Tingkir Tengah Village.

Salatiga's South Ring Road (JLS) has a length of + 11.3 kilometers with a road width of 21 meters, and passes through 3 sub-districts with 7 villages. The JLS development aims to anticipate traffic congestion in Salatiga City, optimize transportation networks in Salatiga City, and spur economic growth in Salatiga City and its surroundings. Other than that, it’s aim to increase the level of service for road users passing through Salatiga City, developing the area, and adding to the national road network system. In addition, JLS is also expected to change the pattern of traffic movements in Salatiga City. In addition, as explained in the Salatiga City Regional Spatial Plan (RTRW) 2010-2030, the development of the ring road network is one of the strategies for developing a transportation network aimed at facilitating the inter-center movement of activities.

![Administration Map of Salatiga City](a) Administration Map of Salatiga City

![Location of The South Ring Road](b) Location of The South Ring Road (JLS)

**Figure 1.** Illustration of the study area
2.2. **Delineation area**

In identifying the relationship between the ring road and land use transformation, the observation unit used is the Zone, so the research area is delineated into eight zones. This delineation is decided based on spatial characteristics, distance from the ring road, and administrative boundaries. These eight zones are then given the same treatment in accordance with the predetermined relationship parameters. These zones include:

| Zone | Area (ha) | Distance from Ring road (m) | Administration Boundaries |
|------|-----------|----------------------------|---------------------------|
| 1    | 633.35    | 500                        | Pulutan, Blotongan        |
| 2    | 756.28    | 3000                       | Bugel, Salatiga, Sidorejo Lor |
| 3    | 406.07    | 5000                       | Kutowinangun Lor, Kauman Kidul |
| 4    | 771.82    | 500                        | Dukuh, Kecandran          |
| 5    | 547.76    | 3000                       | Tegalrejo, Mangunsari, Kalicacing |
| 6    | 623.80    | 3000                       | Gendongan, Sidorejo Kidul, Kutowinangun Kidul, Ledok |
| 7    | 1396.43   | 500                        | Kumpulrejo, Cebongan, Randuacir, Noborejo |
| 8    | 412.15    | 3000                       | Tingkir Tengah, Tingkir Lor, Kalibening |

To verify the relationship, we used scoring method. The parameters used are:

2.3. **Trip attraction**

In this study, the trip attraction calculated using the indicator of generation and area of land use. The generation used is the generation standard adopted from ITE 9th Edition in 2012, illustrated in the following formula:

\[
\text{Trip Attraction} = \text{building floor area} \times \text{trip rate}
\]

| Land Use          | ITE 9th Edition Rate |
|-------------------|----------------------|
| Industrial        | 1000 SF              | 0.73                |
| Residential       | Dwelling Units       | 1                   |
| Tourism           | Acres                 | 4.3                 |
| Conservation Area | Acres                 | 0.84                |
| Public Facility   | 1000 SF              | 7.3                 |
| Office            | 1000 SF              | 1.21                |
| Service           | 1000 SF              | 26.15               |
2.4. **Accessibility index**

Accessibility analysis aims to identify the level of community’s affordability to facilities in a zone. In this study, researchers used a simple calculation adopted from the Minister of Settlement and Regional Infrastructure’s Regulation Number 534 / KPTS / M / 2001. The calculation uses the parameters of road length and area.

2.5. **Population density**

Population density is used to identify activities in a zone. The more densely populated, the more generated generation. In this study, population density was calculated using the formula:

\[
\text{Population Density} = \frac{\text{population}}{\text{area}}
\]

2.6. **Distance from ring road**

The distance from the south ring road is used as a relationship parameter, which is delineated using a buffer of 500 m, 3000 m, and 5000 m from the ring road. The buffer was calculate using administration boundaries and transport activity from each zone.

From these parameters, researcher determines the weight of each. Weighting the parameters uses the Ranking Method, and the determination of the value of each parameter uses the Guttman Scale. After that, the researcher calculates the multiplication score between weight and value. In determining the weight, the researcher uses Number Ranking method, with the formula:

\[
W = \frac{(n - r + 1)}{\sum (n - r + 1)}
\]

Table 3. Weight and Value of the Parameters

| Parameter              | Weight | Range         | Class | Value |
|------------------------|--------|---------------|-------|-------|
| Population density     | 0.1    | 0-2.33        | Low   | 1     |
| (population/ha)        |        | 2.34-4.67     | Medium| 2     |
|                        |        | 4.68-7        | High  | 3     |
| Distance from ring road| 0.4    | 0-500         | Near  | 3     |
| (meter)                |        | 501-3000      | Medium| 2     |
|                        |        | 3001-5000     | Far   | 1     |
| Trip attraction        | 0.2    | 0-509         | Low   | 1     |
| (trip/hour/ha)         |        | 510-1018      | Medium| 2     |
|                        |        | 1019-1526     | High  | 3     |
| Accessibility index    | 0.3    | 0-0.05        | Low   | 1     |
| (meter/ha)             |        | 0.06-0.1      | Medium| 2     |
|                        |        | 0.11-0.15     | High  | 3     |
From these parameters, researcher divides three typology of relationship, which were low relationship which had a total range of scores from 0 to 1.7, medium relationship which had a total score of between 1.8-2.2, and high relationship which had a total score of 2.3-2.6.

3. Relationship between South Ring Road Development and Land Use Transformation

3.1. Land use transformation in Salatiga City

Land use transformation in Salatiga City is relatively fast, indicated by significant land use increase figures. The most significant transformation is in the use of conservation areas, housing and industrial area. The conservation area has a growth index of 12.6 from an area of 39.14 hectares to 532.48 hectares. Beside, residential use has an area of 1,740.24 hectares in 2011 and increased to 2,338.14 hectares in 2016. In addition, the industrial has an increase index of 2.06 which has an increase from 67.6 hectares to 207.18 hectares.

Furthermore, land use which has the lowest transformation index is public facilities which only increased by 0.1 hectares and the military area which only increased by 3.39 hectares. Whereas there is land use that has decreased, namely office land use from 27.29 hectares to 21.33 hectares, forest land use from 183.55 hectares to 167.92 hectares, and agricultural land use from 3,234.46 hectares to 1,384.36 acres. For more details, see the following maps and graph below:

(a) Salatiga’s land use in 2011
(b) Salatiga’s land use in 2016

Figure 3 Land Use Transformation in Salatiga City (map version)
3.2. Scoring the relationship

Based on the formula specified in the method section, the results of the calculation are as follows.

Table 4. Results of The Calculation from Each Zone Based on The Formula

| Zone | Population density | Distance from RR | Trip attraction | Accessibility index |
|------|--------------------|-----------------|----------------|---------------------|
| 1    | 2.292              | 500             | 1221.743       | 0.081037449        |
| 2    | 5.189              | 3000            | 1526.497       | 0.151728954        |
| 3    | 4.2245             | 500             | 259.8225       | 0.113590286        |
| 4    | 2.375              | 500             | 968.08         | 0.068615178        |
| 5    | 6.92               | 3000            | 893.4204       | 0.140372613        |
| 6    | 5.853              | 500             | 987.6508       | 0.121898882        |
| 7    | 1.9025             | 500             | 1132.242       | 0.058785453        |
| 8    | 2.772              | 3000            | 96.64958       | 0.086481666        |

Identification of relationship using the scoring method described in the research method section. Parameters used in determining the score for each zone are: population density with a weight of 0.1, distance from ring road with a weight of 0.4, accessibility index with a weight of 0.2, and trip attraction with a weight of 0.3. The results are as follows.

Table 5. Relationship Scoring

| Zone | Population density value | Distance from RR value | Trip attraction value | Accessibility index value | Total score | Relationship status |
|------|--------------------------|------------------------|-----------------------|--------------------------|------------|--------------------|
| 1    | Low                      | Near                   | High                  | Medium                   | 2.5        | High               |
| 2    | High                     | Medium                 | High                  | Medium                   | 2.6        | High               |
| 3    | Medium                   | Far                    | Low                   | High                     | 1.7        | Low                |
| 4    | Low                      | Near                   | Medium                | Medium                   | 2.3        | High               |
| 5    | High                     | Medium                 | Medium                | Medium                   | 2.4        | High               |
| 6    | High                     | Far                    | Medium                | High                     | 2          | Medium             |
| 7    | Low                      | Near                   | High                  | Medium                   | 2.5        | High               |
| 8    | Medium                   | Medium                 | Low                   | Medium                   | 1.8        | Medium             |

From the table above, three types of relationship were identified, namely High Relationship, Medium Relationship and Low Relationship. Zones that have high relationship are Zone 1, Zone 2,
Zone 4, Zone 5, and Zone 7. Whereas Zone 6 and Zone 8 have the type of Medium Relationship, and Zone 3 has the type of Low Relationship. For more details, see the following map:

![Figure 5. Map of the relationship level](image)

4. Discussion

Land use transformation in Salatiga City is dominated by the interaction of land use in residential, commercial & services, social facilities, and agriculture. This land use transformation has led to an increase in attraction in certain zones, due to the growth of new activity center that have considerable attraction, such as education and commercial & services. In addition to trip attraction, the transformation of land use also affects the level of accessibility of a zone because of the increasing activity center, the road infrastructure also increases, and accessibility also increases. This increase in attractiveness and accessibility affects the relationship between transportation and land use axis.

Therefore, there are also some findings that affirm Babcock's Axial Theory, but there are also some that are not suitable with the theory. As mentioned in the previous section, the transportation axis will affect the changes in land use around it and increase the level of accessibility in the area. This is evident in the case of this study, that the South Ring Road (JLS) was able to attract a fairly high trip, clarified by the addition of social facilities (education) and commercial & services that began to popping up after the ring road operated.

Based on the discussion in the above points, there are also some findings that affirm Babcock's Axial Theory, but there are also some that are not in harmony with the theory. As mentioned in the previous section, the transportation axis will affect the changes in land use around it and increase the level of accessibility in the area. This is evident in the case of this study, that the South Ring Road (JLS) was able to attract a fairly high trip, clarified by the addition of social facilities (education) and trade & services that began to mushroom after JLS operated.
On the other hand, the results of the study show that not all zones that are close to JLS have the highest relationship between the other zones. In addition, the zone close to JLS has a moderate level of accessibility. This contrasts with Babcock’s statement and affirms Apituley’s statement that there are many factors related to road and land use.

5. Conclusion and recommendations

Based on the results of the discussion, not all zones that are close to JLS have the highest relationship compared to the other zones. It is precisely the zone that is at the center of city activity and is 500-3000 meters from JLS which has the highest connection. This can be indicated by a higher score of population density, trip attraction, and accessibility compared to other zones. In contrast to Babcock’s statement in which states that the closer to the axis of transportation, the higher the relationship. In addition, the zone located on the JLS axis has a high attraction, because it is in entrance and exit of the JLS.

The zone near JLS actually has a low population density, but the pull score is high. This affirms Babcock’s statement that activity will be increasingly crowded into the transport axis. In this case commercial & service activities, not housing activities. It can be seen in the spatial transformation around JLS that is significant in the use of commercial & services.

On the other hand, the results of the study show that not all zones that are close to ring road have the highest relationship between the other zones. In addition, the zone close to ring road has a medium level of accessibility. Therefore, there needs to be an evaluation of the South Ring Road (JLS), because it can relate to controlling the use of land use around the road, which should not have high activity that disturbs the activities of JLS.

6. References

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