The Role of Road Database in Supporting Road Network Development Analysis for Regional Development

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Abstract. Analysis of regional accessibility is very important in regional development, where good accessibility is needed to support regional development, especially for potential areas. In the accessibility analysis, it is necessary to have regional spatial data that shows the potential of the area, and accurate road network data including geometric and road network conditions required for accessibility calculations, in which the data derived from the road database were the main and accurate data source. Penukal Abab Lematang Ilir (PALI) is a new district in South Sumatra and has great plantations and mining potential. PALI District continues to develop its road network to improve regional accessibility. The road database for PALI District has been developed since 2017 and has complete road data covering 162 roads with a total length of 555.85 km. This paper discusses the development of regional accessibility, through road improvement and road network development in PALI District using the existing spatial plan and road database. The calculation of accessibility was carried out using the principle of regional connectivity and considering the effect of distance and road network conditions. The network scenario was developed and the accessibility analysis provided the best road network development plan for the regional development of PALI District.

Keywords: Accessibility, Road Database, Regional Development.

1. Introduction

For a development of a region, an effective connecting network is a prerequisite for ensuring connectivity support for potential regions and support for the region's internal and external accessibility so that the regional development plans can be implemented as planned.

Area-related accessibility studies have also been widely discussed [1-6]. The previous study [7] stated that in ranking the area's accessibility, the road network's length and condition are very influential. Thus, in ranking the regional accessibility, it is necessary to enter the parameters of length and road conditions.

To calculate the accessibility, accurate and complete data on the existing road network are needed; consequently, the road database's role is essential in calculating regional accessibility. PALI District has a comprehensive road database and is regularly updated.

PALI District has various natural resource potentials. Based on the existing regional spatial plan, there are 12 activity centers to be developed which are grouped into Centers of Local Activity (CLA), Center of Promotion Local Activity (CPLA), Center of Regional Service (CRS ), and the Center of Environmental Service (CES).
This study discusses the development of the road network in PALI District by taking into account the regional development plan, the location of the area that has natural resource potential and is supported by the existing road database. The accessibility calculation was based on the calculation of the connectedness matrix with respect to road length and road conditions [7]. The network being developed is aimed at improving the accessibility within the region and from and outside the region. The final result of this research is a road network development plan ready to support the Regional Development Plan in PALI District.

2. Methodology

The research steps are shown in Figure 1 with the following explanation:

- The data required for the accessibility calculation were in the form of Potential Area Data obtained from the regional spatial plan. The network, geometric and road condition data were obtained from the Road Database of PALI District.
- The Potential Area Data and Exiting Road Network were used to create alternatives for road network development.
- The role of databases in providing data required for the discussion was to see the importance of databases in Area Accessibility Analysis.
- The final stage of the analysis was to find out the best road network alternative in regional development.
- In this study the total accessibility matrix was calculated based on the connectedness matrix. Several studies in improving regional connectivity in Indonesia using the total accessibility matrix have been reported [8-10].
Apart from the regional connectivity, the road lengths and conditions were used in the Accessibility Calculation Analysis. The steps for calculating accessibility are described as follows:

1. Identifying link and node in existing network.
2. Defining connectivity matrix, in which the cell matrix value is between 0 to 1, depending on the connectivity, length and condition of the road. A basic matrix is a connectivity matrix that explains direct connectivity between regions. To include the influence of the road’s length on the connectivity matrix, the matrix cell between two vertices that have the shortest distance is given a value of 1 while the other matrix cells are given a value by dividing the shortest path length by the road length between the two road vertices. The influence of road conditions is included in the calculation by multiplying the percentage of the length of the road that has good conditions [7].
3. Calculating the accessibility matrix.

The following are the phases of the calculation process of accessibility matrix [11]:

1. Arranging the initial network matrix based on road network map and name it \( C^0 \) on the matrix. Specifying Matrix \( T = C^0 \) and initial value \( n = 1 \). Then check if each element on the matrix \( T \) has no zero value. If not, then \( m = 1 \) and directly proceed to step 5
2. Calculating \( m = n + 1 \) and \( C^m = C^0 \times C^n \)
3. Calculating \( T = T + C^m \)
4. Stopping the iteration when the matrix \( T \) has no elements of 0 value, if any element is zero, \( n = m, C^m = C^n \), and return to Step 2.
5. If the iteration is terminated, the last \( T \) is the total accessibility matrix and \( m \) is the network diameter.
6. Calculating the accessibility value of node.

\[
\text{Accessibility of nodes } i = \left( \sum_j t_{ij} \right) - t_{ii}
\]

3. Existing Network Condition and Network Development Plan

3.1. Regional Potential and Development Plan

In the Regional Spatial Plan (RTRW) of PALI District [12], based on the regional's potential, a Regional Development Plan for PALI District has been formulated and shown in Table 1 and Figure 2.

Table 1. Potential Development Areas

| No. | Category | Location | Allotment                           |
|-----|----------|----------|-------------------------------------|
| 1   | CLA      | Pendopo  | Central Government                  |
| 2   | CPLA     | Sungai Ibul | Trades and Local Transport Meeting Point |
| 3   | CRS      | Talang Akar | Agriculture and Entrance and Exit Area |
| 4   | CRS      | Prabumenang | Mining and Planation               |
| 5   | CRS      | Air Itam  | Agriculture                          |
| 6   | CRS      | Perambatan | Trades and Marketing                |
| 7   | CRS      | Betung Barat | Economics and Social Services       |
| 8   | CRS      | Kertadewa  | Village-Scale Transport Meeting Point |
| 9   | CES      | Sungai Baung | Residential and Agricultural Centers |
| 10  | CES      | Simpang Tais | Mining and Planation              |
| 11  | CES      | Modong    | Entrance and Exit Area             |
| 12  | CES      | Bumi Ayu  | Tourism Area                        |
There are 12 development regional plans in PALI District, where Pendopo is the development center. Areas to be developed are in the form of trade centers, plantations, mining, social and economic services, tourism areas, and access points from and out of PALI District. The development areas need to improve their accessibility, both within the region and outside the region by appropriately developing a road network.

3.2. Existing Road Network Condition and Role of Database

Analysis of the existing road network was used to see how the existing road network could support the Regional Development Plan of Pali District. It was conducted by looking at the inter-regional connectivity with the road network, especially the development area's connection. The existing road network and the development area plan are shown in Figure 3.

Figure 3 shows that several development area plans are not well connected, such as Betung Barat, Prambatan and Modong so that a Road Development Plan is needed to improve the accessibility of potential areas. Currently there are two main accesses out of Pali District, namely through Talang Bulang (node-15) to Muara Enim District and via Kota Baru (node-18) to Musi Banyuasin District. There are two exit accesses that have not been properly opened, namely through the Semangos and Modong Rivers which open access to Musi Rawas District and Muara Enim District. The development of the road network has to pay attention to the shortcomings of the existing road network in supporting the regional accessibility.

![Figure 2. Potential areas for Development](image-url)
In this study, the data of network, geometric and road conditions were obtained from the road and bridge database having been developed by PALI District. The availability of data was needed to calculate the accessibility; the road network development planning process could be done more quickly and accurately. The data used include:

- Road geometric data (length of road sections);
- Street coordinating data; and
- The data on the value of road conditions which in 2019 the value of road conditions was started to be collected using IRI data from the Roadroid.

The main menu display of PALI database is shown in Figure 4, in which the database menu consisted of the data input, data view, reporting, road handling history, and road and bridge libraries. An example of displaying geometric data and the road conditions of a road is shown in Figures 5 and 6. The road and bridge database of PALI District has complete data covering 162 roads with a total length of 555.86 km. The road length and condition data on the existing road network used in the analysis are shown in Table 2.

![Figure 3. Existing Road Network and Development Area Plan](image)

| No | Origin       | Destination  | Road Name | Length (m) | Width (m) | IRI Value Min | IRI Value Max | % Good and Moderate |
|----|--------------|--------------|-----------|------------|-----------|---------------|---------------|---------------------|
| 1  | Sungai Ibul | Tanjung Baru | K32       | 6          | 5         | 4.6           | 8             | 90                  |
| 2  | Sungai Ibul | Pendopo      | K32, K50  | 18         | 5         | 3.1           | 8.4           | 90                  |
| 3  | Sungai Ibul | Babat        | K50       | 12.2       | 6         | 2.9           | 8.8           | 87                  |
| 4  | Sungai Ibul | Talang Akar  | K124, K80 | 13.4       | 6         | 3.2           | 9.4           | 85                  |
| 5  | Gunung Menang| Tanjung Baru| Jalan Provinsi | 14.1 | 6         | 3.2           | 9.1           | 90                  |
| 6  | Gunung Menang| Air Itam     | K52       | 9.2        | 6         | 3.6           | 10.1          | 90                  |
| 7  | Gunung Menang| Sukareja     | Jalan Provinsi | 6          | 6         | 2.9           | 7.3           | 90                  |
| 8  | Prabumenang | Tanjung Baru| Jalan Provinsi | 7.4 | 6         | 4.2           | 9.4           | 95                  |
The data shown in Table 2 were needed to calculate accessibility in the context of regional development. With a complete road database, the local accessibility calculations can be done more quickly and accurately.

The road and bridge database is very useful in developing the road network besides being used for road maintenance planning in an area.

### 3.3. Road Network Development Plan

The road network development plan was based on the need in increasing the accessibility of areas, especially the potential regions. In addition, the road networks were developed to improve the accessibility into and out of the regions.

![Main Menu of Database](image)

**Figure 4.** Main Menu of Database
Based on the condition of the existing road network, the network development was carried out as follows:

- Increasing accessibility to the potential areas of West Betung (node-28), Prambat (node-29) and Modong (node-25) by developing or improving road conditions to the area.
- Improving accessibility to and from Pali District by making better access through Semanggos (Node-26) and Modong (node-25) connecting Pali District with Musi Rawas District and Muara Enim District.
- Connecting several nodes to improve access such as between Talang Akar (node-7) and Kota Baru (Node-18), between Talang Akar and Sungai Baung (Node 13).
Figure 7 shows the developed road network plan. To see the effect of the road network development plan on regional accessibility, the accessibility ranking of the road network development plan was compared to the existing accessibility ranking.

4. Accessibility Analysis

Area accessibility is calculated based on area connectivity, road length, and conditions. Previous studies have shown that road lengths and conditions greatly influence the results of accessibility ranking [7].

The results of the comparison of the regional accessibility rankings for the existing conditions and road network development scenarios are shown in Table 3, where the first step in the calculation was to find out the connectivity matrix. The connectivity matrix of the existing network conditions and road network development plan is shown in Tables 4 and 5.

Table 3 shows that a road development plan being able to improve the accessibility of the area is described as follows:

- With the addition of the road network to West Betung (node-28) and Prambatan (node-29) which are the development centers of the regional service area, there has been a significant improvement in accessibility, especially to West Betung.
- After developing the network, the best regional accessibility is only in Penukal Abab Subdistrict, the accessibility of the area changes where Abab Subdistrict is also an area with good regional accessibility.
- For access outside the region, the road development scenario adds accesses from and out of the District via Semanggos (node-26) to Musi Rawas District and via Modong (node-25) heading for Muara Enim District, so that the accessibility to and from the region gets better.
• Opening the regional accessibility for remote areas that need it, such as Muara Ikan (node-27).

Table 3. Recapitulation of Accessibility Ranking Results

| No. | Location   | Existing | S  |
|-----|------------|----------|----|
| 1   | Sungai Ibul| 11       | 17 |
| 2   | Gunung Menang| 4      | 6  |
| 3   | Prabu Menang| 8      | 11 |
| 4   | Tanjung baru| 9      | 13 |
| 5   | Pendopo    | 19       | 24 |
| 6   | Babat      | 1        | 3  |
| 7   | Talang Akar| 23       | 21 |
| 8   | Air Itam   | 5        | 5  |
| 9   | Simpang Tais| 17     | 23 |
| 10  | Tempirai  | 10       | 14 |
| 11  | Panta Dewa | 7        | 8  |
| 12  | Sinar Dewa| 16       | 18 |
| 13  | Sungai Baung| 24     | 28 |
| 14  | Handayanimulya| 20   | 25 |
| 15  | Talang Bulang| 21    | 27 |
| 16  | Tanjung Kurung| 6     | 2  |
| 17  | Karang Agung| 3      | 1  |
| 18  | Kota Baru  | 15       | 15 |
| 19  | Tanding Marga| 12     | 12 |
| 20  | Pangabuan  | 18       | 16 |
| 21  | Harapan Jaya| 13     | 9  |
| 22  | Sukaraja   | 14       | 10 |
| 23  | Tanah Abang| 22       | 20 |
| 24  | Gunung Raja| 2       | 4  |
| 25  | Modong    | 19       |    |
| 26  | Semanggos | 29       |    |
| 27  | Muara Ikan| 26       |    |
| 28  | Betung Barat| 7      |    |
| 29  | Prambatan | 22       |    |

5. Conclusion

This study discusses the analysis to increase the regional accessibility in PALI District for local development. Based on the condition of the existing road network, the location of the potential area to be developed and the access to and from Pali District, a road network development scenario was developed in Pali District. In addition to maintaining and increasing the existing accessibility of potential areas, the developed scenario opens access to potential areas and into and out of Pali District. With a complete road database, the regional accessibility calculations can be conducted more quickly and accurately.
Table 4. Connectivity Matrix of Existing Road Network

|          | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | 24  |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Suaga   | n   | n   | n   | 0.299| n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Giamur.translation | 0.399| 0.399| 0.299| n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Prahnu | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Suaga   | n   | n   | n   | 0.099| n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Senta  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Bantik  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Suaga   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Senta  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Bantik  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Suaga   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Senta  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Bantik  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |

Table 5. Connectivity Matrix of Developed Road Network Plan

|          | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | 24  |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Suaga   | n   | n   | n   | 0.415| n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Prahnu | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Suaga   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Giamur.translation | 0.299| 0.299| 0.099| n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Prahnu | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Suaga   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Senta  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Bantik  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Suaga   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Senta  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Bantik  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Suaga   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Senta  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |
| Bantik  | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   | n   |

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