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Development Of Integrated Transportation System To Enhance Inter-District Connectivity In Jayawijaya Regency

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Abstract
Transportation plays a central role in supporting regional development, particularly in areas with challenging geographical conditions such as Jayawijaya Regency in the Papua Mountains Province. To date, approximately 45% of the 27 districts in Jayawijaya still face isolation due to poor road infrastructure. This condition directly impacts community access to markets, public services, and the distribution of goods and services. This study aims to design an integrated transportation system that can improve connectivity between districts by considering local geographical conditions. The method used combines Geographic Information System (GIS) for road network mapping, Integrated Rural Accessibility Planning (IRAP) for priority route planning, and Structural Equation Modeling–Partial Least Squares (SEM-PLS) to analyze the causal relationship between infrastructure quality, connectivity, economic accessibility, and local economic growth. The results of the GIS analysis show significant disparities between districts, with most road networks in poor to very poor condition. The SEM-PLS tabulation data proves that infrastructure quality (X1) has a significant effect on economic accessibility (X3) and economic growth (Y), while connectivity (X2) has no direct effect on growth. The mediation pathway X1→X3→Y proved significant, emphasizing the crucial role of infrastructure as a key factor in development. This study confirms that improving the quality of transportation infrastructure, followed by a strategy for integrating transportation services, is a strategic step to encourage sustainable economic growth in Jayawijaya, particularly in the agriculture, trade, and tourism sectors.

INTRODUCTION

Jayawijaya Regency has one of the most challenging geographic conditions in Indonesia. Its mountainous and steep topography limits accessibility between regions. According to Statistics Indonesia (BPS) (2024), over 40% of the inter-district road network is in severe disrepair, while most districts remain isolated from each other. This hampers the distribution of goods, slows community mobility, and suppresses local economic growth.

Limited transportation infrastructure has a broad impact on people's lives. For example, farmers struggle to transport their produce to markets, traders face high distribution costs, and tourists struggle to reach potential destinations. This aligns with the findings of Murtazova et al. (2021) that the quality of transportation infrastructure directly impacts the efficiency of goods distribution and investment attractiveness.

In the Jayawijaya 2021–2026 Regional Medium-Term Development Plan (RPJMD), the regional government prioritizes transportation infrastructure development as a strategic priority to improve public welfare. However, budget constraints and extreme geographic conditions often slow down transportation infrastructure development. Therefore, a data-driven strategy is needed that can help prioritize transportation routes appropriately and provide a clear picture of the relationship between infrastructure quality, accessibility, and economic growth.

State of the Art

Several previous studies (Schindler & Kanai, 2021; Qiao & Huang, 2022) have emphasized the relationship between infrastructure development and economic performance in urban or coastal areas. However, research focusing on the context of remote mountainous areas is limited. Jayawijaya, as a region without sea access and with rugged terrain, provides a unique context to test the effectiveness of an integrated transportation system.

The novelty of this research lies in the integration of three analytical approaches—GIS, IRAP, and SEM-PLS—to design transportation strategies in remote areas. Furthermore, this study emphasizes the impact of transportation on three vital sectors: agriculture, trade, and tourism, which have received little attention in the literature on remote transportation development.

METHODS

Research Design

This study uses a quantitative approach with an explanatory design, aiming to analyze causal relationships between latent variables. This approach was chosen because it can explain the role of transportation infrastructure in improving connectivity and local economic growth in Jayawijaya Regency.

Analysis Method

1. **Geographic Information System (GIS)**
    a) Used to map the condition of inter-district transportation networks, including roads, bridges, terminals, and airport access.
    b) GIS helps identify damaged routes and the spatial distribution of connectivity between regions.
    c) Spatial data was obtained from relevant agencies (BPS, PUPR, and Bappeda Jayawijaya).
2. **Integrated Rural Accessibility Planning (IRAP)**
    a) IRAP is used to determine priority transportation routes based on three main indicators: travel time efficiency, travel costs, and level of community need.
    b) The results of IRAP are in the form of a priority route map that will support increased connectivity between districts.
3. **Structural Equation Modeling – Partial Least Squares (SEM-PLS)**
    a) SEM-PLS is used to analyze the causal relationship between variables:
        1) X1: Quality of Transportation Infrastructure
        2) X2: Inter-District Connectivity
        3) X3: Economic Accessibility
        4) Y: Local Economic Growth
    b) The analysis was carried out in two stages:

1) Outer Model: tests the validity and reliability of indicators.
2) Inner Model: tests the path coefficients between constructs, R^2, and mediation effects.

Research Data

1. Primary: Results of a survey of 71 respondents from 27 districts in Jayawijaya Regency. The questionnaire includes 60 indicators (15 for each construct X1, X2, X3, Y).

Secondary: BPS data (2024), Jayawijaya Regency RPJMD (2020), and field observation results regarding road conditions

RESULTS AND DISCUSSION

1. GIS Mapping Results

GIS mapping results show that road conditions between districts in Jayawijaya Regency remain highly unequal. Districts located near the Wamena city center tend to have better road access, while remote districts face poor or very poor road conditions.

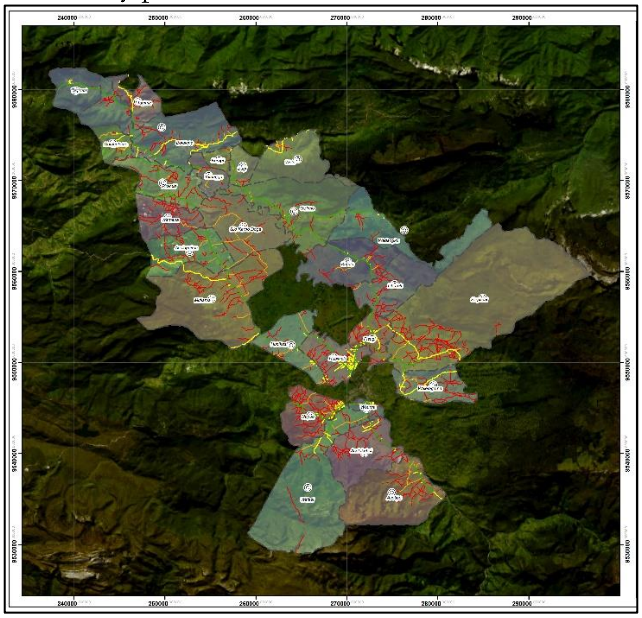

Figure 1. Map of road conditions between districts in Jayawijaya Regency
(line description: green = good, yellow = moderate, orange = quite bad, red = very bad)

2. District Area

A regional analysis reveals significant disparities. Larger districts generally face greater access challenges.

Table 1. Area of districts in Jayawijaya Regency

NO	DISTRICT NAME	Wide
1	Asologaima	3538.17767
2	Asolokobal	3990.855486
3	Asotipo	5942.73735
4	Bolakme	7286.396074
5	Bugi	1033.416425
6	Hubikiak	2395.171025
7	Hubikosi	2817.551967
8	Koragi	613.8456226
9	Kurulu	4124.418986
10	Libarek	3341.299312

11	Molagalome	1244.701484
12	Muliama	9344.883377
13	Napua	2866.524891
14	Pyramid	3108.310339
15	Pisugi	1783.907072
16	Siepkosi	19138.62651
17	Silo Karno Doga	4412.702216
18	Tagime	1609.71914
19	Tagineri	2199.000219
20	Usilimo	6369.844652
21	My place	4263.114341
22	Walelagama	2670.364372
23	Wame	2497.350859
24	Welesi	9732.998585
25	Hello	3557.741099
26	Wouma	500.2337021
27	Yalengga	1120.158513

3. Distribution of Road Conditions Between Districts

Based on field classification and observation, road conditions can be divided into four categories: good, moderate, quite bad, very bad.

a) Good (12 districts): Hubikiak, Pisugi, Kurulu, Libarek, Wosilimo, Yelengga, Bolakme, Asoligaima, Pyramid, Napua, Asolokobal, Wouma.

b) Medium (3 districts): Asotipo, Siepkosi, Wolo.

c) Quite Bad (8 districts): Bugi, Muliama, Tagime, Tagineri, Usilimo, Wadangku, Walelagama, Welesi.

d) Very Bad (4 districts): Koragi, Silo Karno Doga, Wame, Molagaleme.

Table 5. Distribution of road conditions between districts

Category	Number of Districts	Percentage
Good	12	44.4%
Currently	3	11.1%
Pretty Bad	8	29.6%
Very bad	4	14.8%

4. SEM-PLS Analysis Results

To analyze the relationship between latent variables, SEM-PLS was used. The analysis was carried out in two stages:

a. Outer Model (Validity and Reliability Test)

The results of the outer model test show that all indicators are valid and reliable.

Table 2. Summary of Outer Model SEM-PLS

Construct	Number of Indicators	Cronbach's α	Composite Reliability	AVE	Information
X1 (Infrastructure Quality)	15	0.999	1,000	0.999	Valid & reliable
X2 (Connectivity)	15	0.999	1,000	0.999	Valid & reliable
X3 (Economic Accessibility)	15	0.999	0.999	0.999	Valid & reliable
Y (Economic Growth)	15	0.999	1,000	0.999	Valid & reliable

All constructs have Cronbach's α values > 0.7, CR > 0.7, and AVE > 0.5, thus meeting the validity and reliability criteria.

b. Inner Model (Causality Test)

Inner model analysis is used to determine the strength of the relationship between constructs.

Table 3. Inner Path Coefficients of SEM-PLS Model

Track	β coefficient	Significance	Information
X1 → X2	0.85	Significant	Accepted
X1 → X3	0.80	Significant	Accepted
X2 → X3	0.18	Significant	Accepted
X1 → Y	0.58	Significant	Accepted
X2 → Y	0.07	Not significant	Rejected
X3 → Y	0.34	Significant	Accepted

The results show that X1 (Infrastructure Quality) has the most dominant influence on other variables.

c. Mediation and Total Effects

The indirect effect test was conducted using bootstrapping (2000 resamples).

Table 4. Indirect and Total Effects (Bootstrapping)

Mediation Path	Coefficient	Significance	Information
X1 → X2 → Y	0.06	Not significant	Rejected
X1 → X3 → Y	0.27	Significant	Accepted
X1 → X2 → X3 → Y	0.05	Not significant	Rejected
Total Effect X1 → Y	**0.96**	Significant	Accepted

path X1→X2, X1→X3, X2→X3, X1→Y, X2→Y, X3→Y with coefficients at each arrow

5. Discussion

a. Dominant Role of Infrastructure

The analysis results show that infrastructure quality (X1) is the dominant factor in improving connectivity (X2), accessibility (X3), and economic growth (Y). This is consistent with research by Chen (2022) and Qiao & Huang (2022), which found that investment in road infrastructure has a significant impact on economic efficiency.

b. The Role of Connectivity

Inter-district connectivity (X2) does not directly impact economic growth, but plays a role in increasing accessibility (X2→X3 is significant). This means that connectivity will impact the economy only if it translates into tangible access in the form of shorter travel times, lower transportation costs, and reliable distribution of goods.

c. Accessibility as a Mediator

The X1→X3→Y path is significant, confirming that economic accessibility is a key mediator. Better infrastructure allows farmers to sell their crops quickly, traders to distribute goods more efficiently, and the tourism sector to be more accessible.

d. Distribution of Road Conditions and Their Implications

The distribution of road conditions shows that only 44.4% of districts have good road conditions, while the other 44.4% are categorized as fairly poor to very poor. This explains why infrastructure quality (X1) appears as the dominant variable in SEM-PLS.

e. Policy Implications

1. Rehabilitation priority: Roads in very poor condition (Koragi, Silo Karno Doga, Wame, Molagaleme) should be the top priority.

2. Increased accessibility: Focus on routes that connect large districts with the city center, so that the economic impact is greater.

Strengthening vital sectors: Improving transportation infrastructure will accelerate growth in the agriculture, trade, and tourism sectors.

CONCLUSION

The results of the study indicate that the condition of inter-district roads in Jayawijaya Regency is still uneven. Of the 27 districts, only 44.4% have good road conditions, while the rest are in the moderate (11.1%), quite poor (29.6%), and very poor (14.8%) categories. SEM-PLS analysis shows that infrastructure quality (X1) has a significant effect on connectivity (X2), economic accessibility (X3), and economic growth (Y). However, connectivity (X2) does not have a direct impact on economic growth, but rather serves to increase accessibility (X2→X3) which in turn drives growth. Economic accessibility (X3) plays an important mediator, as evidenced by the significant path X1→X3→Y. Furthermore, the total effect of X1 on Y is very strong ($\beta = 0.96$), confirming the dominance of infrastructure quality in driving local economic growth. Based on these findings, policy recommendations are directed at prioritizing the rehabilitation of roads in very poor condition in the districts of Koragi, Silo Karno Doga, Wame, and Molagaleme, as well as improving access in districts with large areas so that the economic impact is greater and more evenly distributed.

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