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Analysis of Road Network System Development Plans and Strategies in West Papua

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Abstract

Manokwari Regency's development of a road network system is crucial to accelerating the improvement of the status of national roads, which are currently disrupting the convenience of road use and the surrounding community due to the degree of saturation being in category F, which includes limited traffic flow, low speed, volume below capacity, and a lack of safety features. Strategy III of West Papua Province's constructed road network system adaptations to local contexts and national hospitality strategies is selected using the Equal Important, Expert Judgment, and Analytical Hierarchy Process methodologies. Next, conduct a SWOT analysis, leading you to an IFE of 3.0 and an EFE of 2.86. To take advantage of chances and lessen the impact of threats, it is necessary first to identify the strategies of aggressive SO. Specifically, 64 SO techniques were identified by having managers and city planners mix 8 strength elements with 8 opportunity components. Unfortunately, few of these chimerical strategies performed well. West Papua's managers and city planners identified six feasible SO solutions to improve the city's transportation system.

Keywords: road; improvement; strategy; equal important, expert judgment, analytical hierarchy process, SWOT analysis.

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1. Introduction

Road infrastructure facilities and infrastructure have become the basic service level in the road sector. At the same time, they are breaking down the geographical isolation of isolated locations, lowering expensive costs, and increasing the quality of life for the people [1,2]. As a result of Manokwari's selection as the capital city of West Papua Province, the city's function has evolved to that of a Regional Activity Centre, operating as a centre for providing services, a processing centre, and a transportation node for several districts. Because the inadequate availability of transport infrastructure services in West Papua Province is the most significant barrier, a commitment to and an action plan for developing transport infrastructure are required. This is because transport infrastructure development is anticipated to speed up regional development in an integrated manner [3,4,5].

The current situation is that various regency roads are located in the Manokwari area, which is a service centre and transportation node with a concentration on Drs. Esau Sesa - Maruni with a length of 21.43 km and an existing width of 4-6 m. This condition is made worse by the degree of road saturation in category F, which includes limited traffic flow, low speed, volume below capacity, and frequent stops [6,7]. The convenience of nearby neighbourhoods and the quality of life for residents are both affected by these problems [8,9]. As a result of this road segment's potential to be upgraded to the status of a provincial road, regional development will be accelerated in an integrated manner.

According to regional potential, criteria for developing a road network system include government centers, tourist attractions, markets, agriculture, and population density. Administrative criteria include the

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suitability of the RTRW, road functions, land readiness, spatial analysis, and policies regarding legislation and indigenous peoples. [10, 11].

In an effort to attain the Sustainable Development Goals (SDGs 2030) and the Long-Term Strategy for Low Carbon and Climate Resilience (LTS LCCR 2050), governance, sustainable development, and urban resilience are the primary focuses of the construction and improvement of road infrastructure. Thus, efforts to mitigate and adapt to climate change and hydrometeorological disasters, which have become a trend in recent years in Indonesian territory, including West Papua, necessitated road enrichment. [12, 13, 14].

Based on this concept, this study was carried out to re-evaluate the state of district roads with the potential to be raised to provincial road status. This study seeks to examine the priority development of the road network system and then identify the strategies and policies required for transforming these roads into provincial roads. [15,16].

2. Material and methods

2.1. Study area

In general, this study will employ three (three) road network system development designs as a strategy [11]:

1. Strategy I: Establish a road network system (RNS) proposed by the West Papua Provincial Government (Figure 1).
2. Strategy II: Central Government proposed road network system (RNS) development (a road network system development plan that considers city roles as outlined in the West Papua Provincial Spatial Plan) (Figure 2).
3. Strategy III: Compilation of road network system development plans from the local and national governments, considering equity and growth (Figure 3).

The three preliminary designs will be researched and compared to select one technique to construct a road network system development program in West Papua Province.

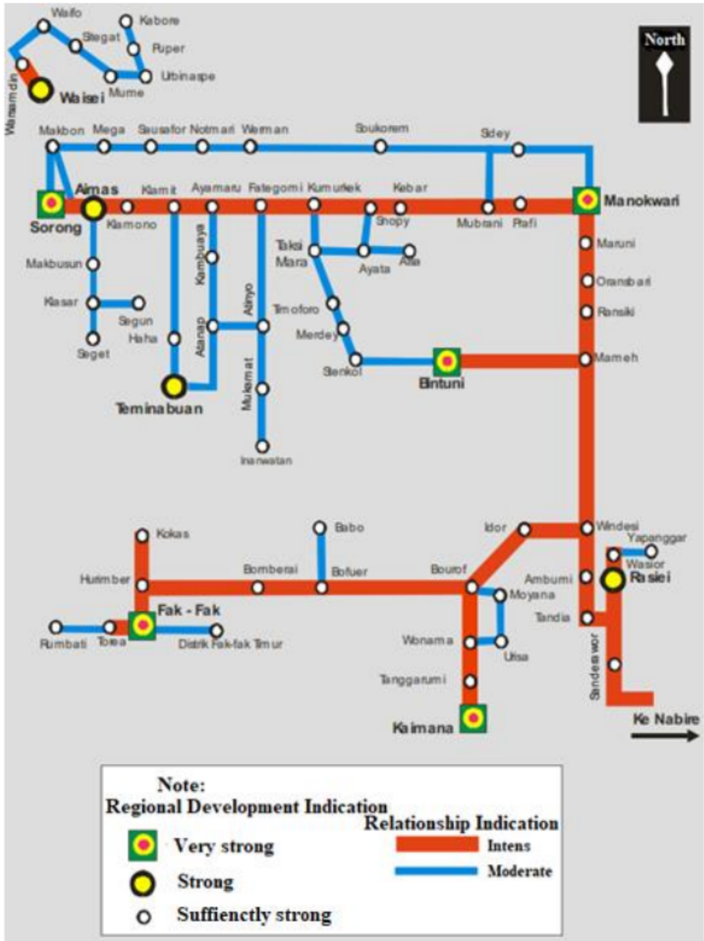

Figure 1. RNS proposed by West Papua Provincial Government

Figure 2. RNS proposed by Central Government

Figure 3. RNS proposed by local and national

2.2. Method of data analysis

Impact prediction measures the plan's impact and benefits against specified scenarios. The road network development objectives to be attained are used to determine economic, social, spatial, technical, and service criteria [17,18]. To assist the assessment of the previous requirements, they must be reduced to comparable indications and parameters. So that the positive and negative aspects of each technique may be determined. The Equal Important, Expert Judgment, and Analytical Hierarchy Process methods, which are an analysis of the results of interview surveys to find out the opinions of experts on the level of importance of each criterion and indicator, can be used to determine the weight of each criterion and indicator [19,20,21].

2.2.1. Economic criteria

The Net Present Value (NPV) technique will be used to calculate benefit indicators, the Economic Internal Rate of Return (EIRR) method will be used to produce return on investment indicators, and the RUC (Road User Cost) will be computed from the three developed strategies for managing the road network system. The Integrated Road Management System (IRMS) program will be used to calculate the three ways. The higher the NPV and EIRR values, the higher the value supplied, whereas the opposite is true for the RUC value. The net present value (NPV) is the rupiah value of current road or bridge handling if road or bridge maintenance is performed in the following years with the equation presented in below [22,23]:

$$NPV = \sum_{i=1}^{i=30} \frac{[RUCR_i + ACR_i] - [RUC_i + AC_i]}{(1+\frac{DISC}{100})^i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 1$$

which NPV = net present value, $RUCR_i$ = road user cost for the referral program in year i, ACR_i = government allocated for referral program in year i, RUC_i = road user costs for the project program in year i, AC_i = government allocated for the project program in year I, and DISC = % rate of reduction.

The economic internal rate of return (EIRR) is used to calculate the interest rate to attain an NPV value of zero. Knowing the current interest rate as well as its future tendencies allows for the implementation of an activity. The IRR must exceed the current interest rate. If the IRR is smaller, it can be stated that the implementation expenses would be more profitable if spent elsewhere. The EIRR equation [24,25] can be shown as follows:

$$EIRR = \sum_{t=o}^{n} \frac{B_t}{(1+i)^t} = \sum_{t=o}^{n} \frac{C_t}{(1+i)^t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 2$$

which EIRR = external internal rate of return, B_t = benefit per year, C_t = Cost per year, t = year, and n = age plan.

2.2.2. Spatial criteria

The SLQ (Simple Location Quotient) method [26,27] will calculate leading sectors that are indicators of regional development. This method compares the regional potential of each district and province to that of the nation. As shown in Table 1, this theory will employ a 1 (one) comparison value to indicate the sector being analyzed to be included in the category.

Table 1. SLQ method categories

Value	Condition
≥ 1	Sectors with indications of export activity (base sector)
1 – 0.05	Non base sector
< 0.05	Sector that lacks support for regional products

The formula used for SLC calculations can be seen below:

$$SLQ^{K_i} = \frac{X^{K_i} / \sum X^{K_i}}{X^{R_i} / \sum X^{R_i}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3$$

which SLQ^{Ki} = simple location quotient of sector i for regency, X^{Ki} = sector i product in district or province Gross Regional Domestic Product (GRDP), and X^{Ri} = sector products in provincial or national GRDP.

2.2.3. Social criteria

On the basis of social criteria, indicators of welfare and the poor population would be weighed against movement. The nature of costs (cost) characterizes the level of welfare, whereas the nature of benefits characterizes the poor. At the welfare level, it is thought that an area is prosperous if it has a big percentage of families with family members who have received tertiary education. As a result, we do not emphasize treatment of these areas. In this indicator, the smaller the multiplication value between the number of families with college-educated family members and the number of movements of each approach, the better. In contrast, the poor population indicator assumes that the greater the number of movements that pass through a poor area, the better the chance for that region's wellbeing. As a result, the bigger the multiplication value of the number of poor families with the number of moves of each method, the more favorable the indicator [28,29].

2.2.4. Technical transportation criteria

The assessment of transportation technical criteria, with indicators of connectivity between modes and modes of transportation, is carried out by estimating the number of infrastructure and transportation facilities in the area traversed by the road network system under development. The larger the daily traffic going through this location, the higher the value. The presence of a terminal, wharf/port, and/or airport in the area is referred to as transportation infrastructure in this indicator. While the means of transportation referred to in this indicator are the number of families in the area who own 2 (two) or 4 (four) wheeled vehicles [30,31].

2.2.5. Service criteria

Regarding service criteria, the regional accessibility indicator includes the criterion of the availability of a public road network. The accessibility index value given in km units of road length for each km2 unit of area to be served (km/km2) is the unit for analyzing regional accessibility. The population mobility indicator includes a road network accommodating community mobility/movement. The mobility index value given in kilometers of road length per 1,000 residents (km/1,000 population) is the unit for analyzing mobility. Each metric will be multiplied by the quantity of daily traffic from each strategy to compare indicators of regional accessibility and passenger mobility from each road network system development strategy that will be implemented. The more beneficial the road network system is, the higher the value derived from the multiplication result [32,33].

Following the determination of which strategy was produced in West Papua Province, policy and strategy analysis with a SWOT analysis was employed in road enrichment efforts focusing on governance, SDGs 2030, and LTS LCCR 2050.

The process of finding, analyzing, and assessing potential 12 useful internal and external variables is known as the SWOT analysis, which is an abbreviation for the word 9 "strengths" (S), "weaknesses" (W), "opportunities" (O), and “threats” (T). The subsequent steps must be performed to construct the matrix of strengths, weaknesses, opportunities, and threats [34,35]:

1. Internal factor identification, including significant strengths and weaknesses, and the creation of the internal factor evaluation matrix (IFE).
2. Internal factors, including significant opportunities and dangers, are identified, and an external factor evaluation matrix (EFE) is created.
3. Create an internal-external matrix.
4. The weighting is calculated using the respondents' responses and then multiplied by the rating (1-5, very low-extremely high) to generate a score for each internal and external aspect.
5. Formulation of strategy recommendations using the SWOT (strengths, weaknesses, threats, opportunities) matrix.
6. To select the five best strategies and policies based on weighting, ranking, and scoring.

3. Results and discussion

3.1. Determination of the selected strategy

The ranking and weighting of the criteria and indicators will be performed before performing the overall assessment stage of each strategy's criteria and indicators. In this study, the Equal Important, Expert Judgment, and Analytical Hierarchy Process (AHP) techniques were ranked and weighted, as shown in Tables 2, 3, and 4 [36, 37, 38].

Table 2. Weight of criteria and indicators using equal important

No	Criteria	Weight	Indicator	Weight
1	Economic	0.20	Benefit	0.067
			Internal rate of return	0.067
			Road user costs	0.067
2	Spatial	0.20	Development area	0.100
			Protected forest area	0.100
3	Social	0.20	Prosperity	0.100
			Poverty	0.100
4	Technical transportation	0.20	Intermodal Connectivity	0.100
			Transportation tool	0.100
5	Service	0.20	Accessibility	0.100
			Mobility	0.100

Table 3. Weight of criteria and indicators using expert judgment

No	Criteria	Weight	Indicator	Weight
1	Service	0.46	Accessibility	0.350
			Mobility	0.120
2	Spatial	0.26	Development area	0.190
			Protected forest area	0.070
3	Economic	0.16	Benefit	0.100
			Internal rate of return	0.040
			Road user costs	0.020
4	Technical transportation	0.09	Intermodal Connectivity	0.070
			Transportation tool	0.020
5	Service	0.04	Accessibility	0.030
			Mobility	0.010

Table 4. Weight of criteria and indicators using analytical hierarchy process

No	Criteria	Weight	Indicator	Weight
1	Social	0.29	Prosperity	0.160
			Poverty	0.130
2	Spatial	0.24	Development area	0.140
			Protected forst area	0.100
3	Economic	0.19	Benefit	0.080

No	Criteria	Weight	Indicator	Weight
1	Social	0.29	Prosperity	0.160
			Poverty	0.130
2	Spatial	0.24	Development area	0.140
			Protected forst area	0.100
			Internal rate of return	0.060
			Road user costs	0.050
4	Technical transportation	0.16	Intermodal Connectivity	0.090
			Transportation tool	0.070
5	Service	0.12	Accessibility	0.070
			Mobility	0.050

Then, as shown in Table 5, determine the standardization of values and the selected strategy [39,40].

Table 5.

No	Criteria	Indicator	Parameter	Standardization of values			Point of equal important			Point of expert judgement			Point of AHP		
				Strg I	Strg II	Strg III	Strg I	Strg II	Strg III	Strg I	Strg II	Strg III	Strg I	Strg II	Strg III
1	Economic	Benefit	NPV	0,841	0,796	1,000	0,056	0,053	0,067	0,034	0,032	0,040	0,050	0,048	0,060
		Internal rate of return	EIRR	0,190	0,000	1,000	0,013	0,000	0,067	0,004	0,000	0,020	0,015	0,000	0,080
		Road user costs	RUC	1,000	0,000	0,713	0,067	0,000	0,048	0,100	0,000	0,071	0,050	0,000	0,036
2	Spatial	Development area	number of leading sectors to movement	0,661	0,669	1,000	0,066	0,067	0,100	0,126	0,127	0,190	0,093	0,094	0,140
		Protected forest area	number of movements of roads passing through protected forests	1,000	0,976	0,000	0,100	0,098	0,000	0,070	0,068	0,000	0,100	0,098	0,000
3	Social	Prosperity	the number of families whose members are in college education	1,000	0,992	0,661	0,100	0,099	0,066	0,010	0,010	0,007	0,130	0,129	0,086
		Poverty	number of poor families	0,661	0,669	1,000	0,066	0,067	0,100	0,020	0,020	0,030	0,106	0,107	0,160
4	Technical transportation	Intermodal Connectivity	number of transportation infrastructure	0,661	0,669	1,000	0,066	0,067	0,100	0,046	0,047	0,070	0,059	0,060	0,090
		Transportation tool	number of means of transportation owned	0,661	0,669	1,000	0,066	0,067	0,100	0,013	0,013	0,020	0,046	0,047	0,070
5	Service	Accessibility	vehicle km / area	0,659	0,669	1,000	0,066	0,067	0,100	0,231	0,234	0,350	0,046	0,047	0,070
		Mobility	vehicle km/1000 population	0,661	0,669	1,000	0,066	0,067	0,100	0,079	0,080	0,120	0,033	0,033	0,050
	Total value						0.73	0.65	**0.85**	0.73	0.63	**0.92**	0.73	0.66	**0.84**

Table 5 data demonstrate that strategy III was adopted. In certain ways, the development of the road infrastructure system is adapted to local situations as well as national hospitality strategies.

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3.2. SWOT analysis

3.2.1. Internal factor

The first step in developing the internal factor evaluation matrix is to rank the weaknesses and strengths of the current transportation system in West Papua Province. Thirty city transportation experts and planners were polled for their thoughts on the matter. Impact or importance was determined after identifying internal elements through questionnaires and consulting with experts. Each strength and weakness is given a number between 0 and 1 so that the sum of the coefficients equals 1 [41,42]. This allows us to determine the degree to which the internal components are impacted. Each discovered internal factor was also given a score between 1 and 4, with 1 indicating extreme weakness, 2 normal weakness, 3 normal strength, and 4 extreme strength [43]. The final score is determined by multiplying the weight by the ranking. Table 6 displays the weight, rank, and score of the identified internal components [44].

Table 6. Result of internal factors (strengths and weaknesses)

No	Strengths	Weight	Ranking	Score
1	Environmental impact assessment document	0.05	3	0.15
2	Regional spatial plans	0.05	3	0.15
3	There are roads that are 4-6 meters wide	0.20	4	0.80
4	Acceleration of the local economy	0.10	4	0.40
5	Improve the investment climate	0.05	3	0.15
6	Enhance social and economic activities	0.05	3	0.15
7	Reduce regional isolation	0.10	3	0.40
8	Significant potential for industrial agriculture	0.05	3	0.15
	Sub Total	**0.65**		**2.35**
No	**Weaknesses**	**Weight**	**Ranking**	**Score**
1	Low Human Development Index	0.15	2	0.30
2	Disparities in geography and geography	0.10	2	0.20
3	Not yet planned for in low-carbon development	0.01	2	0.02
4	Without considering climate resiliency	0.01	2	0.02
5	High degree of road saturation	0.02	2	0.04
6	Air pollution	0.01	1	0.01
7	Noise pollution	0.01	1	0.01
8	Discomfort for road users	0.01	1	0.01
9	Feelings of discomfort for the community around the road	0.01	1	0.01
10	there is no green open space	0.01	2	0.01
11	Limited transportation facilities and infrastructure	0.01	2	0.02
	Sub Total	**0.35**		**0.65**
	Total	**1.00**		**3.00**

3.2.2. External factor

The opportunities and threats were identified in the second phase of the SWOT analysis. West Papua did the same for the transportation sector by compiling expert opinions in Table 7. Once identified, external factors followed the same evaluation process as internal ones to determine their importance and relative ranking. In reality, the scores 1, 2, 3, and 4 represented the most basic, typical, and most basic levels of understanding [45]. Table 7 displays the weight, ranking, and final score for the most important opportunities and threats in the field of transportation [46].

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Table 7. Result of external factors (opportunities and threats)

No	Opportunities	Weight	Ranking	Score
1	Road widening to 25 meters for 21.43 km	0.15	4	0.60
2	Compensation costs	0.15	4	0.60
3	National construction funds	0.10	4	0.40
4	Easy access to vehicle loans	0.01	3	0.03
5	Smooth agricultural supplies	0.03	3	0.09
6	Reducing traffic congestion	0.05	3	0.15
7	Free-market of Asia-Pacific Economic Cooperation (APEC) and AFTA (ASEAN region)	0.01	3	0.03
8	Decentralization and Special Autonomy	0.05	3	0.15
	Sub Total	**0.55**		**2.05**
No	**Threats**	**Weight**	**Ranking**	**Score**
1	High hydrometeorological disaster	0.15	2	0.30
2	High Disaster Risk Index	0.05	2	0.10
3	Mangroves have been destroyed	0.01	2	0.02
4	The road drainage system has multiple points of degradation	0.01	1	0.01
5	Climate change issues	0.01	1	0.01
6	Land conflicts due to road widening	0.05	1	0.05
7	Low traffic order	0.01	1	0.01
8	High traffic accidents	0.01	1	0.01
9	Realizing equitable development	0.05	2	0.10
10	Accelerating district and provincial economic growth	0.05	2	0.10
11	Enhancing infrastructure, services, and transportation	0.05	2	0.10
	Sub Total	**0.45**		**0.81**
	Total	**1.00**		**2.86**

3.2.3. Evaluation of the transportation system's status

Following this phase of SWOT implementation, a preferred situation will have been chosen among the four possible ones (aggressive, competitive, conservative, and defensive), and appropriate measures for enhancing sustainable transportation in West Papua will be provided [47]. To put it another way, we can compare and contrast internal and external elements using the corresponding matrices. Using an evaluation matrix, the current state of the transportation network in West Papua can be specified. The final scores obtained from the internal and external factor assessment matrices are placed in the vertical and horizontal dimensions, respectively, to construct the matrix, determine status of the transportation system, and select the most effective techniques. This matrix, which is similar to a strengths, weaknesses, opportunities, and threats (SWOT) analysis, details the best strategies for bolstering the transportation system. The ranking of the transportation system was determined by subtracting the sum of the scores on the internal and external factor matrices. The sum of the external factors' scores is 2.86 (Table 7), while the sum of the internal factors' scores is 3.00 (Table 6). The matrices for internal and external factors and their corresponding scores, are depicted in Figure 4. Figure 4 shows that the West Papua transportation system is currently stable. It's important to note that the transportation system is in an aggressive domain if Internal Factor Evaluation (IFE) is greater than 2.5 and External Factor Evaluation (EFE) is greater than 2.5. The West Papua transportation system is aggressive, with IFE=3.0 and EFE=2.86; as a result, SO techniques can be identified to take advantage of opportunities and mitigate the strength of threats [48].

When taking a cautious stance, SO techniques offer the most potential for enhancing the transportation system. That is to say, the aggressive strategy's primary goal is to use existing chances to strengthen the transportation system from within. As a result, Table 8 displays the aggressive methods that have been extracted from the confluence of the transportation system of strengths and opportunities in West Papua. To this purpose, managers and city planners combined 8 strength variables with 8 opportunity factors to identify 64 SO tactics. Most of these hybrid approaches, however, were not particularly appealing. Managers and city planners in West Papua have settled on 6 viable SO solutions to enhance the city's transportation network (Table 8) [49,50]. The recommended SO strategies emphasize rapid road enhancements with recommendations on Regional Spatial Planning and Environmental Impact Analysis; local economic improvement, and agricultural product distribution; concerned with low carbon development and climate resilient; and facility and infrastructure referred to decentralization and special autonomy.

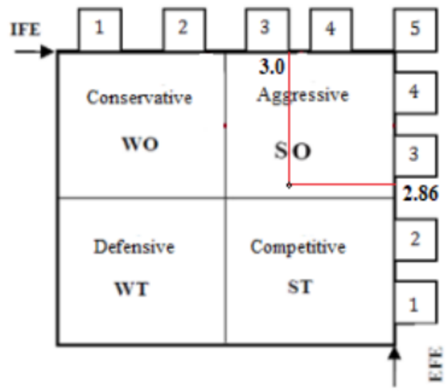

Figure 4. Quadruple situations of SWOT implementation

Table 8. Key strategies for urban transportation system in West Papua

External / Internal	Opportunities
	1. Road widening to 25 meters for 21.43 km
	2. Compensation costs
	3. National construction funds
	4. Easy access to vehicle loans
	5. Smooth agricultural supplies
	6. Reducing traffic congestion
	7. Free-market of Asia-Pacific Economic Cooperation (APEC) and AFTA (ASEAN region)
	8. Decentralization and Special Autonomy
Stregths	**Strategies (SO)**
1. Environmental impact assessment document	SO1. Accelerated road widening is urgently required to alleviate traffic congestion, isolation, and discomfort to users and the general public
2. Regional spatial plans	SO2 The AMDAL analyzed the substantial impacts on road widening and adapted it to the West Papua Provincial Spatial Plan
3. There are roads that are 4-6 meters wide	SO3 Local economy development, financial conditions, and free market competition
4. Acceleration of the local economy	SO4 The delivery of agricultural goods is becoming improved
5. Improve the investment climate	SO5 The focus of road improvements is on low-carbon development, climate change, and disasters.

6. Enhance social and economic activities	SO6 Transportation facility and infrastructure management with a focus on decentralization and special autonomy
7. Reduce regional isolation	
8. Significant potential for industrial agriculture	

4. Conclusion

Using the Equal Important, Expert Judgment, and Analytical Hierarchy Process methods for road network system development, the study reveals that the third strategy chosen is compiling road network system development plans from the local and national governments, considering equity and growth (strategy III).

Furthermore, to obtain strategy and policy development from strategy III, a SWOT analysis was carried out and obtained IFE and EFE values of 3.0 and 2.86, respectively. Thus, developing policies and strategies for the road network enhancements system in West Papua Province refers to quadruple aggressiveness.

In this study, 8 combined 8 strength variables with 8 opportunity factors to identify 64 SO tactics were obtained. However, managers and city planners define the 6 best tactics by focusing attention on rapid road enhancements with recommendations on Regional Spatial Planning and Environmental Impact Analysis; local economic improvement, and agricultural product distribution; concerned with low carbon development and climate resilient; and facilities and infrastructure referred to decentralization and special autonomy.

Compliance with ethical standards

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Conflict of interest statement

There is no conflict of interest.

Statement of informed consent (*optional*)

Informed consent was obtained from all individual participants included in the study.

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