2018 Matec-icdm evaluation road maintenance

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The evaluation of road maintenance programs, case study: the national road maintenance programs in West Sumatra

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Abstract. Currently, due to the limitation of funding, the national road maintenance programs in West Sumatra which were based on the output from IIRMS (Indonesian Integrated Road Management System) cannot be fully implemented. In order the road maintenance can be carried out effectively according to parameters considered, the ranking of roads priority must be determined. In this study, analyzes were conducted in the determination of national road maintenance priorities. The parameters used are SDI, IRI, road width, and V / C ratio. The methods used were the AHP (Analytical Hierarchy Process), IPA (Importance Performance Index) modification, and CSI (Customer Satisfaction Index) modification. In the study also evaluated the effectiveness of road maintenance program which was made by Satker P2JN, BPJN III compared to the result of the analysis. The result shows that there was still ineffectiveness of road maintenance programs made by BPJN III.

1 Introduction

Based on the Decree of Minister of Public Works and People's Housing in 2015 [1], the length of national road in West Sumatera reaches 1,448,81 KMs. The road consists of 88 non-toll roads.

The national road management in West Sumatra is under the authority of the National Road Implementing Agency III (BPJN III), Ministry of Public Works and People's Housing. The conditions of all national roads in West Sumatra are not in a good category. By 2017, 71.95% of national roads are in good condition, 35.46% are in moderate condition, 10.93% are lightly damaged, and 1.10% is severely damaged.

However, the indicator to determine national road condition in the maintenance program of BPJN III is largely based on the value of IRI (International Roughness Index) which the source of data was taken from IIRMS (Indonesian Integrated Road Management System) output. While the needs of road maintenance should be able to override the traffic performance indicator; those are the degree of saturation (V/C) and the technical requirements to be met, i.e. minimum width for the national road. On the other hand, Road management is constrained by limited funding, the road maintenance budget cannot handle all of the national roads in West Sumatra.

The priority in determining the road segments to be handled was done based on the coordination meeting, both at the regional level (Balai scope) and at the national level (the scope of Directorate General of Highways, Ministry of PUPR). Therefore, this study is expected to be a supporting method that can be used in determining the priority of road handling, so that the funding limitation does not impede to the effectiveness of road handling.

Prior researches conducted on-road handling priorities were well documented. Noviastuti in 2014 evaluated the national road handling program in South Sumatra by using parameters of IRI, road width, and V/C ratio [2]. Sartika (2014) evaluated the road handling program in North Sumatra with parameters SDI, IRI, road width, and V / C ratio. She used IPA and CSI modification methods [3]. Putri (2011) analyzed the priority of Bangli district road handling using AHP method [4]. Antonius, T (2017) conducted a comparison of the priority of provincial roads handling in West Sumatra by using the AHP, AMK, and Bina Marga methods [5].

By the several previous studies, the most factors that influenced in road handling were road conditions and traffic factors.

In this study, the determinations of road handling were based on 4 (four) parameters, i.e. SDI (Surface Distress Index) value, IRI (International Roughness Index) value, road width, and V/C ratio. SDI value is a functional indicator of pavement condition which is obtained from the Road Condition Survey.

Manurung, et al (2015) said that according to the SMD-03 /RCS Road Survey Guidelines IIRMS, the visual observations which are used to determine the SDI values are the crack widths on the road surface, the average crack width, the number of holes /km of road length, and the depth of the wheel/groove [6]. SDI

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values can describe road damage that can predict proper handling to improve the condition of a road.

According to PU Ministerial Decree No.13.PRT /M/ 2011 [7], the value of IRI is already commonly used in the determination of road handling in Bina Marga. Hikmat Iskandar, (2005) in Siahaan, et al (2014) states IRI value was obtained by the longitudinal road profiles measurement [8]. The flatness of the road surface is considered as a resultant condition of the pavement as a whole. If the road surface is flat enough then the road is considered good from the lower layer to the top layer of pavement and vice versa.

Based on the Government Regulation No.34, 2006, the traffic lane width should be able to accommodate the minimum traffic [9]. The traffic lane width also must fulfill the minimum service standards, i.e. safety, and environment condition. Minimum traffic lane width for various road classifications according to the Ministry of Public Works Decree No.19 / PRT / M / 2011 [10] is shown in the following table.

Table 1. Traffic lane width (m)

Type of Road		Traffic Lane width (m)
Primary network system	High way (4/2 D)	2 x (2x3,5) 2 x (3x3,5) 2 x (4x3,5)
	Medium road (2/2 UD)	2 x 3,5
	Small Road (2/2 UD)	2 x 2,75
Secondary network system	High way (4/2 D)	2 x (2x3,5) 2 x (3x3,5) 2 x (4x3,5)
	Medium road (2/2 UD)	7,00
	Small Road (2/2 UD)	5,50

Source: Permen PU No.19 (2011)

While the V/C ratio or degree of saturation is an indicator of road performance. The indicator is based on traffic factors. V/C ratio is used in some traffic regulations to indicate the level of service of a road. If the road capacity is not able to accommodate the traffic volume, it means that the capacity needs to be increased.

There were three purposes of the study, namely; first, to determine the appropriate type of road handling for each segment by using IPA and CSI modification methods, second, to determine the priorities of road segments that need to be maintained, and third, to evaluate the effectiveness of road maintenance program made by Satker P2JN, BPJN III by compared to the result of analysis.

2 Material and methods

This research used 3 (three) methods combined to get the result of road handling type for each road segment and the priority of the road segment to be maintained. The evaluation of the road maintenance effectiveness was conducted by comparing the output of the analysis toward the existing road maintenance program. If the value of the existing program equals the results of the analysis, the conclusion is that the existing road maintenance program is effective. If the value of the existing program was less or did not meet the needs of road handling analysis results, the conclusion is less effective. If the value of the existing program exceeds the road maintenance needs of the analysis results or indicates a waste of costs, the conclusion is ineffective.

2.1 Data

This research used primary and secondary data. Primary data were obtained by distributing a set of questionnaires to 40 respondents (experts). Primary data were used for AHP analysis to determine the weight of the 4 (four) parameters used (SDI, IRI, road width and V/C ratio). The result of data analysis is the ranking of these parameters based on the interest level.

The secondary data used were SDI value, IRI value, road width, and the V / C ratio. Data were obtained from Satker P2JN, BPJN III. In addition, there was the data on road maintenance programs that were obtained from P2JN Satkers in 2017 and 2018. The secondary data covers all national roads in West Sumatra (88 segments).

2.2 Methodology

There are three methods that are used, namely AHP (Analytical Hierarchy Process). The AHP method is used to determine the parameters weight. The analysis also used IPA (Importance-Performance Analysis) and CSI (Customer Satisfaction Index) modification. The flowchart of this research methodology can be seen in Fig 1.

From AHP analysis, it was obtained the weight of parameters used in the determination of road maintenance according to respondents, there were SDI (42,86%), IRI (32,97%), V / C ratio (12,66%), and road width (11.51%). Furthermore, the parameters will be used to establish the IPA Cartesian diagram. The higher ranked parameter (greater weight) will be placed on the X-axis, and the lower-weight parameter will be placed on the Y-axis.

The next analysis is the modified IPA (Importance-Performance Analysis) method. In the modified IPA method, an analysis was performed by using a Cartesian diagram. In this diagram, there are four big quadrants. The boundary between quadrants is defined by the applicable rules regarding the parameters used. This analysis determined the types of road treatment based on the relationship between two parameters.

Quadrant analysis can be seen as follows:

a. Quadrant I shows the main priority of road handling due to bad road conditions based on two parameters used.
b. Quadrant II indicates that the road segment requires more handling of the X-axis parameters used.

c. Quadrant III shows more directed road segments to be handled against Y-axis parameters and the road are in a more tolerable condition.

d. Quadrant IV shows the road segment in good condition and does not require priority of handling.

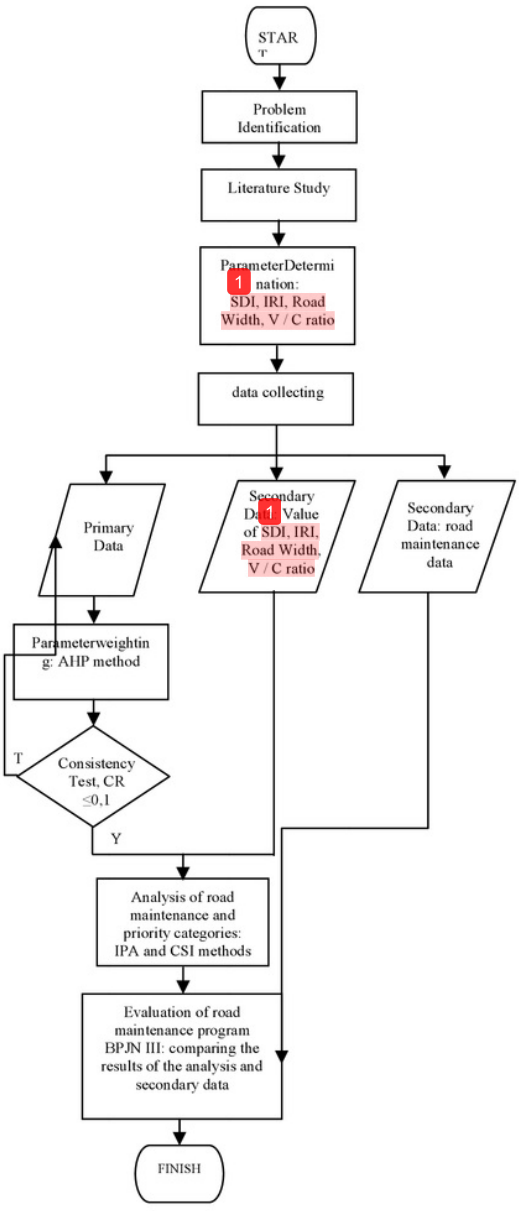

Fig.1. Flowchart of research methodology

The boundaries between the quadrants of each parameter are determined in accordance with the following rules:

a. Based on the SMD-03 / RCS Road Survey Guideline, SDI value> 150, this value indicates the road is in heavily damaged condition, and 100 <SDI ⩽ 150, this value indicates the road is in a slightly damaged condition, so the values 100 and 150 are determined as quadrant boundaries.

a. Based on Ministry of Public Works Decree No. 13/2011 [7] on Road Maintenance and Ownership Procedures, IRI value> 12 shows roads in heavily damaged condition, while the value of 8 <IRI ⩽ 12 shows the road in a slightly damaged condition, so the values 8 and 12 are determined as quadrant boundaries.

b. According to the Ministry of Public Works Decree No.19 of 2011 [7] on Road Technical Requirements and Road Planning Technical Criteria, the minimum requirement of road width for the national road (primary road network) is 7 m.

c. In accordance with MKJI 1997 [11], V / C ratio is a road indicator in a stable or unstable traffic flow. The maximum requirement of the V / C ratio for a stable current is 0.75 so that the value is used as the quadrant boundaries.

There are 6 (six) cartesian IPA diagrams showing relationships between SDI, IRI, path width, and V / C ratio parameters shown in Fig 2.

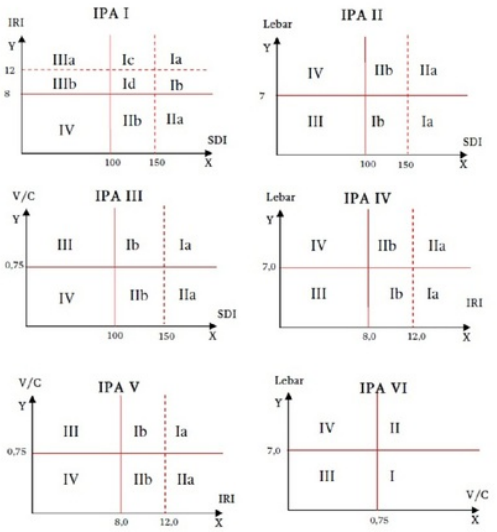

Fig.2. Cartesius diagram

The next analysis was CSI modification that serves to know the priority of each type of handling resulting from IPA I - VI diagram for each segment (Table 2). Aritonang (2005) in Syukri (2014) [12] mentioned the steps to know the value of CSI is:

a. Determine Mean Importance Score (MIS):

$$MIS_i = \frac{\sum_{i=1}^{n} Y_i}{n} x\ 100\ \% \quad (1)$$

n: Number of Data
Y_i: The importance value of an i-j attribute (which has been converted on a predetermined scale)

Table 2. The result of IPA analysis

Quandrant		Early Plan of Road Maintenance					
		IPA I (SDI – IRI)	**IPA II (SDI – Width)**	**IPA III (SDI -V/C)**	**IPA IV (IRI – Width)**	**IPA V (IRI – V/C)**	**IPA VI (V/C - Width)**
I	a	Reconstruction	Reconstruction + Standard Widening	Reconstruction + Standard	Reconstruction + Standard Widening	Reconstruction + Standard Widening	Widening
	b	Reconstruction + Rehabilitation	Rehabilitation + Standard Widening	Rehabilitation + Standard Widening	Rehabilitation + Standard Widening	Rehabilitation + Standard Widening	
	c	Reconstruction + Rehabilitation	-	-	-	-	
	d	Rehabilitation					
II	a	Reconstruction	Reconstruction	Reconstruction	Reconstruction	Reconstruction	Widening
	b	Rehabilitation	Rehabilitation	Rehabilitation	Rehabilitation	Rehabilitation	
III	a	Reconstruction	Standard Widening	Widening	Standard Widening	Widening	Standard Widening
	b	Rehabilitation					
IV		Routine Maintenance	Routine Maintenance	Routine Maintenance	Routine Maintenance	Routine Maintenance	Routine Maintenance

b. EstablishWeight Factor (WF):

$$WF_i = \frac{MIS_i}{\sum MIS} x\ 100\ \% \quad (2)$$

MIS_i: MIS i-j attribute
$\sum$ MIS: The total number of MIS attributes

c. Determine Mean Satisfaction Score (MSS):

$$MSS = \frac{\sum_{i=1}^{n} X_i}{n} x\ 100\ \% \quad (3)$$

n: Number of data
X_i: The performance value of an i-j attribute (which has been converted on a predetermined scale)

d. Establish Weight Score (WS):

$$WS_i = WF_i x MSS \quad (4)$$

WF_i: *Weight factor* of i-j attribute
MSS: *Mean Satisfaction Score*

e. Determine CSI Value:

$$CSI = \frac{\sum_{i=1}^{n} WS_i}{HS} x\ 100\ \% \quad (5)$$

WS_i : *Weight Score*
HS : *HighestScale, maximum scaleused*

The CSI scale for each parameter used to adjust the quadrant in the IPA can be seen in Table 3. Table 4 shows modified CSI criteria from dissatisfied sequences as the highly satisfied priority to not priority.

Table 3. CSI scale of each parameter

Scale	Parameter			
	SDI	**IRI**	**Road width**	**V/C Ratio**
1	> 150	> 12 m/km	< 5,5 m	≥ 0,85
2	100< SDI ≤150	8< IRI ≤ 12 m/km	5,5 ≤ L < 7 m	0,75 ≤ V/C < 0,85
3	50 < SDI ≤ 100	4 < IRI ≤ 8 m/km	7 ≤ L < 14 m	0,45 ≤ V/C < 0,75
4	≤ 50	≤ 4 m/km	≥ 14 m	< 0,45

Table 4. CSI criteria

CSI Value	CSI Criteria
CSI value ≤ a	Priority range I (Main Priority)
a <CSI value ≤ b	Priority range II (Medium Priority)
b <CSI value ≤ c	Priority range III (Low Priority)
CSI value > c	Not priority range

a: minimal value of CSI
b: a + 1/2 (c-a)
c: an average of CSI

The next step is to determine the priority of the segment. The method used is by giving the weight of value for the results of IPA I - IPA VI and CSI I - CSI VI. The road segment with the smallest value weights

will be the priority to maintenance. The weight of the value used in establishing the priority of the road segment was shown in the following table.

Table 5. Weight value in determining the road priority

Weight Value	IPA Quadrant	CSI Criteria
1.00	I	PR I
1.00	Ia	
1.25	Ib	
1.50	Ic	
1.75	Id	
2.00	II	PR II
2.00	IIa	
2.50	IIb	
3.00	III	PR III
	IIIa	
3.50	IIIb	
4.00	IV	BP

The last analysis is an evaluation of the effectiveness of road maintenance programs that have been prepared by P2JN, BPJN III compared to the results of the analysis. The program is said to be effective if the P2JN value data is equal to the result of the analysis. If the program value data is less than the results of the analysis, it is said to be less effective. And if the program data exceeds the analysis results (an indication of a waste of cost) then said to be ineffective.

Rokot-Sioban and SiobanKatiet are the top priorities in 2017 to be addressed. The condition of both roads is very damaged, always affected by rob floods the road width is not wide, the users are difficult to pass the roads

Data on the average condition of these two segments in 2017 are SDI = 165, IRI = 18.69 m / km, width = 4.5 m, and V / C = 0.

Fig.3. Rokot – Sioban

Fig.4. Sioban – Katiet

3 Result and discussion

In accordance with the objectives of the study, there are three outcomes of this study, namely the types of handling of each segment, the priority of the segment that needs to be addressed, and the evaluation of the effectiveness of the road maintenance program by P2JN, BPJN III compared to the results of the analysis.

a. Type of road handling (Analysis Result)
After quadrant analysis is done by using modified IPA method and priority of handling type with modified CSI method, hence can be determined road maintenance program as a reference for the type of road maintenance that is used as a program to exclude the type of maintenance that is included in the CSI criteria "Non-Priority (NP)"..

b. Road segment priority
The determination of road segment priority was conducted by ranking based on the weight of the value which is according to Table 5. The segment with the smallest value weight will be prioritized. Priority of roads that need to be handled immediately based on road condition data of 2017 is shown in Table 6 and 7 below.

4 Conclusion

As the result, SDI is in the top ranking of the parameter that is considered in determining the road priority to be handling, followed by IRI, V / C ratio), and road width. Rokot-Sioban and Sioban Katiet are in the priority for handling, the type of maintenance program for both road segments are Reconstruction + Standard Widening. As the result of the evaluation of the effectiveness of road maintenance programs, based on road maintenance program data (2018), 34.09% of the program are Effective, 57.95% of the program is less effective and 7.95% are ineffective.

Table 6. Priority of roads maintenance

No	Road segments	Length(Km)	Total Value	Ranking	Maintenance programme in 2018 (Analysis Result)
051	Rokot – Sioban	21.00	25	1	Reconstruction + Standard Widening
052	Sioban – Katiet	32.39	25	2	Reconstruction + Standard Widening
021	Simp. Empat - Padang Sawah	41.20	32	3	Widening
040	Bts. Kota Padang Panjang – Sicincin	19.29	32	4	Widening
040 11 K	Jln. St. Syahrir (Padang Panjang)	4.46	32	5	Routine Maintenance + Widening
053	LubukSelasih – Surian	62.58	35	6	Routine Maintenance + Standard Widening
050	Toapejat – Rokot	36.10	36.25	7	Rehabilitasi + Standard Widening
005	Bts. Kota Bukittinggi - Sp. Padang Luar	2.39	37	8	Routine Maintenance + Standard Widening
026	LubukAlung - Simp. Duku	13.49	37	9	Routine Maintenance + Widening
041	Sicincin - LubukAlung	13.51	37	10	Routine Maintenance + Standard Widening

Table 7. The effectiveness evaluation of road maintenance program in 2018

No. Segment	Name &The Condition of Road segment				Maintainance programme 2018 (Analysis result)	Maintainance programme 2018 (Data)	Effectiveness
051	Rokot – Sioban				Reconstruction + Standard Widening	Standard Widening	less effective
	SDI	**IRI (m/km)**	**V/C**	**Width (m)**			
	165.00	18.69	0.00	4.50			
052	Sioban – Katiet				Reconstruction + Standard Widening	-	less effective
	SDI	**IRI (m/km)**	**V/C**	**Width (m)**			
	165.00	18.70	0.00	4.50			
021	Simp. Empat - Padang Sawah				Widening	Routine Maintenance	less effective
	SDI	**IRI (m/km)**	**V/C**	**Width (m)**			
	23.71	2.76	0.98	4.96			
040	Bts. Kota Padang Panjang – Sicincin				Widening	Routine Maintenance + Periodically	less effective
	SDI	**IRI (m/km)**	**V/C**	**Width (m)**			
	37.02	3.31	1.40	6.00			
040 11 K	Jln. St. Syahrir (Padang Panjang)				Routine Maintenance + Widening	Routine Maintenance	less effective
	SDI	**IRI**	**V/C**	**Width(m)**			

No. Segment	Name &The Condition of Road segment	Maintainance programme 2018 (Analysis result)	Maintainance programme 2018 (Data)	Effectiveness
	(m/km)			
	51.09 4.04 1.41 6.65			
053	LubukSelasih – Surian SDI: 76.37 / IRI (m/km): 5.68 / V/C: 0.12 / Width (m): 5.45	Routine Maintenance + Standard Widening	Routine Maintenance	less effective
050	Toapejat – Rokot SDI: 99.45 / IRI (m/km): 9.45 / V/C: 0.00 / Width (m): 5.25	Rehabilitasi + Standard Widening	-	less effective
005	Bts. Kota Bukittinggi - Sp. Padang Luar SDI: 43.38 / IRI (m/km): 3.74 / V/C: 0.86 / Width (m): 7.00	Routine Maintenance + Standard Widening	Routine Maintenance	less effective
026	LubukAlung - Simp. Duku SDI: 27.58 / IRI (m/km): 2.88 / V/C: 2.22 / Width (m): 7.00	Routine Maintenance + Widening	Routine Maintenance	less effective
041	Sicincin - LubukAlung SDI: 31.74 / IRI (m/km): 3.21 / V/C: 0.63 / Width(m): 6.50	Routine Maintenance + Standard Widening	-	less effective

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