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Determination of the Effectiveness of Drainage of National Road Sections Based on DIS Data in Maluku Province

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ABSTRACT

Every five years, periodic maintenance is required for damage to parts of the road, where samples are taken from each location every year to measure the damage weight value and obtain the PPI value, in order to determine whether parts of the road or other supporting buildings need to be preserved periodically or not. IRI survey to measure unevenness components, PCI/SDI survey to measure pavement surface conditions, Benkelmen beam to measure remaining pavement life, Topographic survey, drainage effectiveness ranking to measure ED components and other surveys that support the availability of primary data and secondary data which of course require a lot of time and cost. To determine the ED index value (Effectiveness of Drainage), an approach is needed through PCI data and ED (Effectiveness of Drainage) will be determined or analyzed using the data that has been collected/downloaded, then the data that has been processed after that will be useful for BPJN agencies or the Bina Marga Service/sub-service related to roads/bridges or road implementation because the ED component is an important part of the PPI component. Based on the research results, the ranking is obtained from the calculation of the ED (Effectiveness of Drainage) ranking range

1. INTRODUCTION

The Road Implementation Agency in Indonesia, especially the National Road Implementation Agency (BPJN) in Maluku Province as an extension of the Ministry of PUPR, Directorate General of Highways, has a program that is measurable with PPI (Program Performance Indicator), which is an index that is reported annually and semi-annually to measure whether the achievement of national road implementation in each provincial area has met the target or strategic plan (2020-2024). Based on the Road and Bridge Sector Guidelines No. 07/P/BM/2021 concerning Planning and Programming of Road Network Preservation Work, the program performance indicator (PPI) is determined by 4 components [1] consisting of: a. Unevenness component using the IRI (international roughness index) parameter, b. Pavement Surface Condition component using the PCI (pavement condition index) parameter, c. Remaining Pavement Life component using the RSL (remaining structural life of pavement) parameter, and d. Drainage Effectiveness component using the ED (effectiveness of drainage) parameter. Reporting on the 4 PPI components periodically is not a simple job because it requires resources, various types of surveys are needed such as: IRI Survey to measure unevenness components, PCI/SDI Survey to measure pavement surface conditions, Benkelmen beam to measure remaining pavement life, Topographic survey, drainage effectiveness ranking to measure ED components and other surveys that support the availability of primary data and secondary data which of course require a lot of time and money [2]. Determining the value of one of the PPI component indexes, namely ED, requires alternative steps in order to be efficient in terms of resources and time in preparing data directly (primary data) or indirectly (secondary data). Literature review as Sowolino [3] states, if drainage condition data is limited/unavailable, then the drainage effectiveness ranking can be determined using an approach method, so the solution is to take secondary data through trusted sources, namely the data input system (DIS) application managed by Bina Marga [1] and can be freely accessed by users on the website www.pu.go.id. According to Sowolino [3] it is further stated that the drainage effectiveness components are divided into 2 (two) sub-components, namely: (1) Surface Drainage Condition Sub-Component, and (2) Sub-Surface Drainage Condition Sub-Component (Sub-soil). The Drainage Effectiveness Component ranking is the weighted average of the two sub-components.

2. LITERATURE REVIEW

Road preservation is a program of activities that aims to preserve investment in the national road system, improve pavement performance, extend the life of the pavement, and provide infrastructure for motorists [5] Based on the Road and Bridge Sector Guidelines No.07/P/BM/2021 concerning Planning and Programming of Road Network Preservation Work, the weight of 4 components has been determined, where the weight of each component is determined based on Table .1, namely International Roughness Index (IRI) with a weight of 60%, Pavement Surface Condition/Pavement Condition Index (PCI) with a weight of 10%, Remaining Structural Life of Pavement (RSL) with a weight of 15% and Effectiveness of Drainage with a weight of 15%. These components will determine the value of the Program Performance Index (PPI), where

the target PPI value for each Province has been set in the Strategic Plan of the Directorate General of Highways for 2021-2024 [4].

2.1 Effectiveness of Drainage (ED Components)

The effectiveness of drainage component is divided into 2 (two) sub-components, namely: (1) Surface Drainage Condition Sub-Component, and (2) Sub-Surface Drainage Condition Sub-Component (Sub-soil). The effectiveness of drainage Component ranking is a weighted average of the two sub-components. Surface effectiveness of Drainage is an indication of how well water flows on the road surface. The function of the pavement surface condition and the condition of the road shoulder is the ranking of the surface drainage sub-component. Another supporting factor is the road terrain. Hilly or mountainous areas will be given a better ranking than flat terrain. Subsurface drainage effectiveness is an indication of how well water flows from the road pavement and its surroundings (including "cross drainage"). The ranking of the subsurface drainage sub-component is a function of: (1) the need for subsurface drainage, (2) its design, construction, and maintenance, and (3) the condition of the subsurface drainage infrastructure. If drainage condition data is limited/unavailable, the ranking effectiveness of drainage can be determined using an approach method. For the surface drainage sub-component, an approach is made using PCI condition data and "terrain" data in Table 1 (one), showing how the ranking is given based on the PCI value. The ranking for the "subsoil" drainage sub-component is given according to Table 2 .

Table 1. Scale Index Sub- Component Program Performance Drainage Surface

Ranking Sub-Components Drainage Surface	Description	Combination of PCI and Flat Terrain		Combination of PCI and Hill/ Mountain Terrain	
		Range	Terrain	PCI raw range	Terrain
1	Very Good	PCI > 5	Flat	PCI >70	Hills/ Mountains
2	Good	70<PCI ≤85	Flat	55<PCI ≤70	Hills/ Mountains
3	Currently	55<PCI ≤70	Flat	25<PCI ≤55	Hills/ Mountains
4	Damaged Light	22<PCI ≤	Flat	PCI ≤ 25	Hills/ Mountains
5	Damaged Heavy	PCI ≤25	Flat		

Table 2. Scale Evaluation Index Sub- Component Program Performance "Subsoil" Drainage

Subsoil Drainage Sub-Component Rating	Description	Drainage Infrastructure Available	Terrain
2	Good	Yes	Hills/Mountains
3	Currently	No/No data	Hills/Mountains
3	Currently	Yes	Flat
4	Minor Damage	No/No data	Flat

The final ranking effectiveness of drainage is a weighted average of the two components above with a weighting ratio of 80% surface drainage and 20% subsoil drainage. If one of the two components gets a rating of 5 , then the final ranking must be 5 , because one of the sub-components must be treated. If the drainage condition data is already available, the ranking effectiveness of drainage can be determined in several stages. To provide a ranking of the surface drainage sub-component, an approach is used using data on the condition of the pavement surface, the area and level of damage to the grooves (rutting), and the type, height, and condition of the shoulder. If the shoulder is not covered, the condition value is increased by one (the worse). If the shoulder is higher than the road surface used by traffic, the condition value is increased by one (the worse). Terrain data, if the terrain is hilly or mountainous, the condition value is reduced by one (the better). Table .Three explains how adjustments are made in providing an assessment of the drainage effectiveness ranking with good data availability

Table 3. Factor Adjustment Mark Condition

Factor Adjustment Mark Condition			Description
Medan	Hills / Mountains	-1	The more Good
Shoulder	Without closing	+1	The more Bad
	More tall from surface road	+1	The more Bad

Table 4 below shows the weights assigned to each sub-component of surface effectiveness of drainage. These weights are used to calculate the final rating effectiveness of drainage. If one of the two sub-components is rated 5, then the final rating must be 5, because one of the sub-components must be addressed.

Table 4. Effectiveness Subsoil Drainage

Sub-components Assessed	Weight
Structural conditions	50%
Serviceability	50%

3. METHODOLOGY

3.1 Research Location

This Study was done and reviewed using existing secondary data available from DIS application where source of results data research on the section road national Maluku Province is located on 6 islands that are counted. Which are spread across the city Ambon: 18 sections road national, Buru Regency: 9 sections road national, South Buru Regency: 1 section road national, South Aru Regency: 2 sections national road, Southwest Maluku Regency: 8 sections national road, Regency. Tanimbar Islands: 12 sections national road, Central Maluku Regency: 16 sections national road, Southeast Maluku Regency: 4 sections national road, Seram Regency Part West: 11 sections national road, Seram Regency East Part: 4 sections national road, Tual city: 4 national roads.

Figure 1. Research Location

3.2 Data Types and Analysis Methods

The data sources used in this study are secondary data obtained from BPJN Maluku or related agencies, downloaded from the data input source (DIS) application, exemplified in the Appendix, including:
1. Road Network Map
2. PCI Road Data
3. 2020-2024 Strategic Plan Data

Method Analysis used to determine ED value (Effectiveness of Drainage) as follows:
a. Determine the effectiveness of drainage using PCI (*Pavement Condition Index*) data
b. Do analysis against ED (Effectiveness of Drainage)
c. Process ED results (Effectiveness of Drainage) as appropriate DIS standard
d. Calculation of PPI with combination of 4 components

Secondary data in the form of IRI, PCI, RSL data, conditions drainage surface, and condition drainage lower surface (sub-soil). Data source comes from BBPJN or BPJN representative region in review research, which is shown in Table 5 [6].

Table 5. Secondary data sources for each regional representative

No	Review Area	Data source
1	Representative region 1	Hall Executor Road National Maluku Province

4 RESULTS AND DISCUSSION

4.1 Pavement Condition Index (PCI) Data

PCI (*Pavement Condition Index) data* is secondary data that is available on 89 sections roads in Maluku province , the data recorded on DIS PCI data where processed And analyzed PCI value range results year to year . For long survey from year to year seen from long survey in a way overall [10], by taking into account the length of a section road (KM), then long every section the path under study combined in a way overall And averaged out amount long survey, then obtained results recap long survey (KM) for each period year on overall section researched road . Then For PCI mean value obtained from secondary data that is processed, for One the section divided by 100 (M) where every 100 (M) already attached its PCI value part section divided road combined its PCI value , and averaged out PCI value on a section road the And obtained PCI results on one section road, valid also on other section roads . Then after getting PCI value on each section path, PCI value on sections road the combined the whole thing And averaged out PCI value on section road overall, then obtained PCI average results for each applicable period /year.

PCI value increases down each year and on in 2024 the PCI value is on value 81.138. Change mark This indicates that road conditions on Maluku Province experienced decline (degradation). PCI value on Maluku province experienced decline on in 2021, namely from value 85,782, on in 2022 it will be 78,884, then experience decline on 2023 to 75,884, Increase mark This identifies that condition road on Maluku province experienced improvement of Table 6 [7] [8].

Table 6. Summary of Pavement Condition Index Data

PCI Recapitulation		PCI Recapitulation 2021-2024	
Period	Year	Long Survey KM	PCI Average
PCI 2021	Year 2021	1667.110	85,782
PCI 2022	Year 2022	1647.282	78,884
PCI 2023	Year 2023	1647.263	75,884
PCI 2024	Year 2024	1933.561	81,138

4.2 Secondary Data Analysis of Road Sections in Maluku Province

Done validation for road section based on PCI data. Results validation done for match long section road based on section data road PCI survey results.Validation results displayed on Table 7 shows that difference to long section This will influence mark calculation [10] [11].

Table 7. Secondary Data PCI Value

Link ID	Name Section Road	PCI Value
60007	Amahai - Masohi	90
60008	Masohi - Makariki	86
60009	Makariki - Sp. Waipia	80
60010	Sp. Waipia - Saleman	75
60011	Saleman - Besi	70
60012	Besi - Wahai	69
60013	Wahai - Pasahari	70
60014	Pasahari - Kobisonta	70
60015	Kobisonta - Banggoi	65
60016	Banggoi - Bula	75

4.3 Effectiveness of Drainage in Maluku Province

The effectiveness of drainage component is divided into 2 (two) sub-components, namely: (1) Surface Drainage Condition Sub-Component Table 8 Scale Evaluation Index Sub-Component Program Performance Drainage Surface, and (2) Sub-Surface Drainage Condition Sub-Component (*Sub-soil*) Evaluation Ind Table 9 Scale Sub-Component Program Performance Drainage *"Sub-soil"*. The Drainage of Effectiveness Component ranking is a weighted average of the two sub-components. Surface drainage effectiveness is an indication of how well water flows on the road surface.

The function of the pavement surface condition and the road shoulder condition is the ranking of the surface drainage sub-component. Another supporting factor is the road *terrain*.

1. Sub components drainage surface

Table 8. Scale Evaluation Index Sub-Component Program Performance Drainage Surface

No	Mark PCI	Sub-component ranking Drainage Surface	Description	Combination of PCI and Flat *Terrain*		Combination of PCI and *Terrain* hilly / mountainous	
				Range PCIraw	*Terrain*	Range PCIraw	*Terrain*
1	90	1	Very Good	PCI > 85	Flat		
2	86	1	Very Good	PCI > 85	Flat		
3	80	2	Good	70 < PCI ≤ 85	Flat		
4	75	1	Good	70 < PCI ≤ 85	Flat		
5	70	3	Currently	55 < PCI ≤ 70	Flat		
6	69	2	Currently			55 < PCI ≤ 70	Hill
7	70	3	Damaged Light	25 < PCI ≤ 55	Flat		
8	70	2	Good	70 < PCI ≤ 85	Flat		
9	65	3	Currently	55 < PCI ≤ 70	Flat		

2. Sub-components of subsurface drainage

Table 9. Scale Evaluation Index Sub-Component Program Performance Drainage *"Sub-soil"*

No.	Sub-component ranking Subsoil Drainage	Description	Infrastructure Drainage Available	Terrain
1	3	Currently	Yes Available	Flat
2	4	Damaged Light	No Available	Flat
3	3	Currently	Yes Available	Flat
4	3	Currently	No Available	Proven
5	3	Damaged Light	No Available	Flat
6	3	Currently	No Available	Proven
7	2	Currently	Yes Available	Flat
8	3	Currently	No Available	Proven
9	3	Currently	Yes Available	Flat

3. Factor Adjustment condition

Ranking end effectiveness of drainage is a weighted average from second component namely sub-components drainage surface and sub-components drainage lower sub-soil surface, ED rating can be with a number of stages. To give sub-component ranking drainage surface used approach using condition data surface pavement, area and level of rutting damage, and type, height, and condition of shoulder road. If shoulder No covered so mark condition added one (more and more) bad). If shoulder is taller than surface the path taken Then cross so mark condition added one (more and more) bad). Terrain data, if Medan hills or mountains so mark condition minus one (more and more good). As stated on Table 10.

Table 10. Condition Evaluation Factor

No	Mark Ranking	Factor Evaluation Condition	
		Terrain	Shoulder
1	4	Flat	without cover/more tall from road
2	3	Flat	with cover / more low
3	4	Flat	without cover / more low
4	2	Hilly	without cover / more low
5	5	Flat	without cover / more low
6	2	Hilly	without cover / more low
7	4	Flat	without cover / more low
8	3	Flat	No available drainage
9	3	Flat	No available drainage

4. Effectiveness of Drainage (ED) Value Results

The final ranking is based on the ED value ranking for each road section in Maluku Province. The weight is used to calculate the final ranking of drainage effectiveness. For the surface drainage sub-component, it is weighted at 80% and the sub-surface drainage sub-component "Sub-soil" is weighted at 20%. Where the weight is a provision Based on the Road and Bridge Sector Guidelines No. 07/P/BM/2021 concerning Planning and Programming of Road Network Preservation Work, if one of the two sub-components gets a rating/ranking of 5 , then the final ranking must be 5 , because one of the sub-components must be given treatment.

Determination:

$$ED = 80\% \times S\text{-}DSC + 20\% \times S\text{-}CSD \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Note:

a. 80% = Weight value of Surface Drainage Sub-Component
b. 20% = Weight value of Sub-Surface Drainage Sub-Component
c. S-DSC = Surface Drainage Sub-Component
d. S-CSD = Sub-Component of Subsurface Drainage

In the calculation results of ED (Effectiveness of Drainage) if the value is one then the road section has drainage effectiveness in very good condition on the road section and does not need to do further handling of one of the sub-components or all components (Surface and subsurface drainage). If the ED value is two then the effectiveness of drainage is in good condition. If the ED value obtained is 3 then the effectiveness of drainage in the road section is in moderate condition or does not need further handling. If the ED value obtained is 4 then the drainage effectiveness on the road section is in a condition of minor damage, the condition of the road section is not so severe and can still be accessed by road users but must always be monitored periodically because the road section could experience severe damage quickly. And if the ED value obtained in the calculation is 5, then the effectiveness of drainage is in a condition of severe damage and must be handled immediately because one of the sub-components

(Surface drainage sub-component/Subsurface drainage sub-component) is experiencing problems and severe damage.

Table 11. Effectiveness of Drainage

No	Name Section Road	Sub-Components Drainage Surface	Sub-Components Drainage Lower *Sub - Soil* Surface	Mark Effectiveness Drainage
1	AMAHAI - MASOHI	1	3	1.4
2	MASOHI - MAKARIKI	1	4	1.6
3	MAKARIKI - SP. WAIPIA	2	3	2.2
4	SP. WAIPIA - SALEMAN	1	3	1.4
5	SALEMAN - BESI	3	3	3
6	BESI - WAHAI	2	3	2.2
7	WAHAI - PASAHARI	3	2	2.8
8	PASAHARI - KOBISONTA	2	3	2.2
9	KOBISONTA - BANGGOI	3	3	3

From the Range/ Average PCI value is obtained from results calculation mark effectiveness drainage in a way overall obtained mark **2.00** where for overall section road against 89 sections roads in Maluku Province condition ok (good).

5. Effectiveness of Drainage Diagram

The drainage diagram in Figure 2 is a recapitulation of the drainage of effectiveness ranking graph for 89 road sections in Maluku Province.

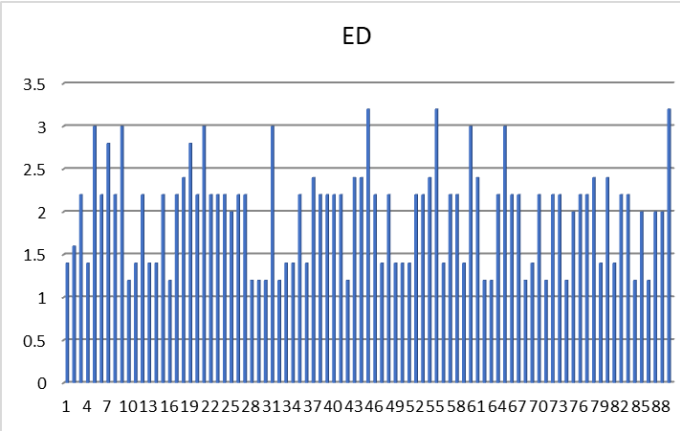

Figure 2. Effectiveness of Drainage Diagram

5. CONCLUSION

In study This determined kanji to weight ED component (Effectiveness of Drainage) obtained based on case condition roads on representative regions in Indonesia. Methods used are collecting supporting data, processing data, and analyzing data for each path represented on each area under study.

Based on results the analysis carried out can conclude that:

1. Weight mark on ED (Effectiveness of Drainage) was obtained from results analysis against secondary data on each section road especially in the section road national Maluku province based on analysis using secondary data. The range value of ED for Maluku province is 2.00
2. To know ED conditions can be seen on ED table (effectiveness of drainage), so that it can be known whether on a condition road section must be done Handling as soon as possible or No only by seeing ED calculation results.
3. On table Scale Evaluation Index Sub-Component Program Performance "Subsoil" Drainage and Factor Adjustment Condition, it can be concluded that availability of drainage greatly influences a need condition road, seen on section of road in distant islands from city Ambon where became point gather trading even others. Each section of the path filled with need adequate drainage different with section road distant islands from Ambon city where Lots section road made without taking in to account need drainage.

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NOMENCLATURE

PPI: Program Performance Index
IRI : International Roughness Index
PCI : Pavement Condition Index
RPL : Remaining Pavement Life
E*D* : Effectiveness of Drainage
DIS : Data Input Source

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