Evaluation of urban drainage network based geographycal information system (GIS) in Sumenep City

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Abstract. Sumenep City frequently hit by floods. Drainage network conditions greatly affect the performance of her maid, especially those aspects that affect the capacity of the drainage channel. Aspects that affect the capacity of the drainage channel in the form of sedimentation rate and complementary buildings on drainage channels, for example, the presence of street inlet and trash rack. The method used is a drainage channel capacity level approach that level assessment of each segment drainage network conditions by calculating the ratio of the channel cross-sectional area that is filled with sediment to the total cross-sectional area wet and the existence of complementary buildings. Having obtained the condition index value of each segment, the subsequent analysis is spatial analysis using ArcGIS applications to obtain a map of the drainage network information. The analysis showed that the level condition of drainage network in the city of Sumenep in 2016 that of the total 428 drainage network there are 43 sections belonging to the state level "Good", 198 drainage network belong to the state level "Enough", 115 drainage network belong to the state "Mild Damaged", 50 sections belonging to the state "Heavy Damage" and 22 drainage network belong to the state of "Dysfunction".

1. Introduction

Drainage network conditions greatly affect the performance, especially those aspects that affect the capacity of the drainage channel. Aspects that affect the capacity of the drainage channel in the form of sedimentation rate and complementary buildings on drainage channels, for example, the presence of street inlet and filter garbage (trash rack). The greater the rate of sedimentation in the channel it will reduce the capacity of the channel which leads to reduced performance of serviceability, as well as if the channel is not equipped with complementary buildings strap water and filter junk then potentially decreased the capacity of the channel.

This study aims to obtain an evaluation value of each segment level condition in Sumenep drainage network, drainage network obtained distribution maps along with the type of building in Sumenep, and get a map of the drainage network in Sumenep based on the level and condition-based maintenance actions on geographical information systems.

If the condition has been arranged to evaluate the extent of drainage network that stretches in Sumenep, the Local Government will be easier to monitor the channels are bad for immediate maintenance action. Especially when the database is presented in the spatial data in a Geographic Information System (GIS) will facilitate the activities of asset development and maintenance [3], [5].

2. Experimental

2.1. Urban Drainage Network Assessment

The government has not issued a regulation on guidelines for condition assessment drainage network. Therefore, in this study the drainage network condition assessment process as a form of evaluation is done with the approach of assessment guidelines existing irrigation networks. Aspects of the assessment will be reviewed from sedimentation rate and completeness of infrastructure and facilities drainage network.

2.2. Sedimentation Aspects Rate

Rate aspect of the rate of sedimentation in the drainage channel made through a Circular Letter Ditjen SDA according to Minister of Public Works No. 02 / SE / M / 2011 on Guidelines for Performance Assessment Network Swamp Reclamation. Sourcebook for assessing the condition of the wet cross-section shown by the index value ranging between 1-5 [1]. The smaller the value of the index shows that the cross section of the wet conditions, the better, which means also that the function of the better wet cross section [2].

Based on the above assessment approach, in this study the function value (%) sedimentation rate assessed by comparing the existing high sedimentation of the channel capacity. Channel capacity is assumed proportional to the maximum channel cross-sectional area, the channel height (H) is the height of water (h) plus high-surveillance (w). Thus, for calculating the maximum cross-sectional area trapezoid-shaped channel (type A) is:

$$A = bH + mH \quad (1)$$

$$H = h + w \quad (2)$$

$$A_{sed} = bH_{sed} + mH_{sed} \quad (3)$$

A = The maximum cross-sectional area (m^2),
A_{sed} = sectional area due to sedimentation (m^2),
b = width of the base line (m),
$1/m$ = slope of the embankments,
H = total channel height (m),
H_{sed} = high channel due to sedimentation (m).

As for calculating the maximum sectional area of a rectangular duct (type B) is:

$$A = bH \quad (4)$$

$$A_{sed} = bH_{sed} \quad (5)$$

Thus, the sedimentation rate can be measured by:

$$Sed = \left(100 - \frac{A_{sed}}{A}\, x\, 100\right)\% \quad (6)$$

Then the calculation results of sedimentation into the condition input values in Table 1:

Table 1. Condition Assessment Based on Sedimentation Rate Drainage Network

Index	Condition	Function (%)	Condition
1	Sedimentation rate is between 76-100%.	76 - 100	Good
2	Sedimentation rate is between 51-75%.	51 - 75	Enough
3	Sedimentation rate is between 26-50%.	26 - 50	Mild Damaged
4	Sedimentation rate is between 1-25%.	1 - 25	Heavy Damage
5	Sedimentation rate to cover the entire cross section of the channel (0%).	0	Dysfunction

2.3. Assessment of Completeness Drainage Network Infrastructure

As aspects of sedimentation, the completeness of infrastructure and facilities drainage network graded into five indices as follows:

Table 2. Assessment of Completeness Drainage Network Infrastructure

Index	Condition	Function (%)	Condition
1	There is a street inlet and trash rack. The building is in good condition, not encountered significant damage.	76 - 100	Good
2	There is a street inlet and trash rack. Buildings under moderate conditions and functioning, found no damage, but can be overcome and functioned.	51 - 75	Enough
3	There is a street inlet or trash rack. Buildings in a damaged condition, encountered damage, do not function properly.	26 - 50	Mild Damaged
4	There is a street inlet or trash rack. Buildings in severely damaged condition, the damage can not be repaired, lost, collapses, and others.	1 - 25	Heavy Damage
5	Buildings or building components do not exist.	0	Dysfunction

2.4. Total Assessment of Drainage Network

Ratings total drainage network is done with the approach Circular of the Minister of Public Works No. 02/SE/M/2011 on Guidelines for Performance Assessment Network Swamp Reclamation. The condition of drainage network is a combination of the index is reviewed aspects of sedimentation condition and completeness of infrastructure and facilities. The index value waterworks condition being simulated is calculated by weighting (SE Ditjen SDA Men PU No. 02/SE/ M/2011), with the following formula:

$$Ik_{\text{drainage}} = \frac{\{(Ik_{sed} \, x \, W_{sed}) + (Ik_{PS} \, x W_{PS})\}}{(W_{sed} + W_{PS})} \qquad (7)$$

Empirically, sedimentation have an influence on a greater capacity than the completeness of infrastructure and facilities. Thus, the weight of sedimentation (W_{sed}) will be greater than the weighting of infrastructure and facilities (W_{PS}). This study used a weight W_{sed}=3 and W_{PS}=1.

If the index value has been obtained drainage network in Sumenep, then the action recommendations can use the approach in the Circular Minister of Public Works No. 02/SE/M/2011 on Guidelines for Performance Assessment Network Swamp Reclamation as follows:

Table 3. Relationship between Line Condition Index and Building, Channel Function and Building, and Recommended Actions

Index	Condition	Recommended Actions
1	Functioning of between 76% to 100%	Routine Maintenance
2	Functioning of between 51% to 75%	Periodic Maintenance
3	Functioning between 26% to 50%	Rehabilitation
4	Functioning between 1% to 25%	Rehabilitation
5	There is no channel and / or buildings which should be available or 0%	Study Design

Source: SE Director General of Water Resources Ministry of Public Works No.02/SE/M/2011

3. Result and Discussion

3.1. Data Analysis Technique

Data analysis was carried out by providing an assessment of the physical condition of drainage network on each segment based on primary and secondary data. Assessment methods physical condition of the drainage network using condition assessment index sedimentation and drainage completeness of infrastructure and facilities, as described in Table 1 and Table 2. The drainage network assessment performed on each channel that is at the crossroads between the roads, but if encountered height differences of different sediment in drainage network segment every crossroads, the division of sections taken at locations or points that indicate the height difference of the sediment.

In addition, the process geographical analysis using ArcGIS version 9.3 software that starts with mapping the drainage network in all regions of Sumenep based spatial data to produce thematic maps drainage network [4].

Then this thematic maps integrated with the results of the physical assessment of drainage networks where this data as attribute data or additional information in thematic maps drainage network. Physical assessment network will appear as the value of the conditions in each network segment depicted in symbols or legends that differ in the thematic maps. These thematic maps can be useful in monitoring and maintenance, precisely a key consideration in decision making maintenance actions.

3.2. Percentage Level Sediments Drainage Network in Sumenep

Based on the measurement results of high sediment and sediment percentage calculation on each side drainage networks exist in Sumenep the obtained results of the investigation, as in Table 4.

Table 4. Percentage Rate of Sediment in Drainage Network

No	**Street Name**	**Location**	**Code**	**B** [a] **(m)**	**H** [b] **(m)**	**M** [c] **(m)**	**Building Type**	**High of Sediment (H_{sed})** [d] **(m)**	**m_{sed}** [e] **(m)**	**Percentage Sediment (%)**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	Dr. Wahidin	Pajagalan	Wahidin-1	0.50	0.70	0.20	A [f]	0.06	0.02	93.67
2	Dr. Wahidin	Pajagalan	Wahidin-2	0.50	0.70	0.20	A [f]	0.10	0.03	89.21
3	Dr. Wahidin	Pajagalan	Wahidin-3	1.05	0.80	0.00	B [g]	0.20	0.00	75.00
4	Dr. Wahidin	Pajagalan	Wahidin-4	0.90	1.15	0.00	B [g]	0.15	0.00	86.96
5	Dr. Wahidin	Pajagalan	Wahidin-5	0.70	1.15	0.20	A [f]	0.14	0.02	90.20
6 to 428	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*

[a] Width of the base line (m),
[b] Total channel height (m),
[c] Slope of the embankments,
[d] High channel due to sedimentation (m),
[e] Slope sediments on embankments (m),
[f] Channel with trapezoidal cross-sectional shape,
[g] Channel with a rectangular cross-sectional shape.

Table 5. Levels and Recommended Actions Condition Drainage Network

No	Code	Sediment Factor	Infrastructure & Facilities Factor	Sediment Condition Index Values	Values Infrastructure & Facilities Condition Index	Total Value Index	Condition (%)	Condition Level	Recommended Actions
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	Wahidin-1	3	1	1	2	1.25	68.75	Enough	Periodic Maintenance
2	Wahidin-2	3	1	1	2	1.25	68.75	Enough	Periodic Maintenance
3	Wahidin-3	3	1	2	3	2.25	43.75	Mild Damaged	Rehabilitation
4	Wahidin-4	3	1	1	4	1.75	56.25	Enough	Periodic Maintenance
5	Wahidin-5	3	1	1	3	1.50	62.50	Enough	Periodic Maintenance
6 to 428	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*	*(etc)*

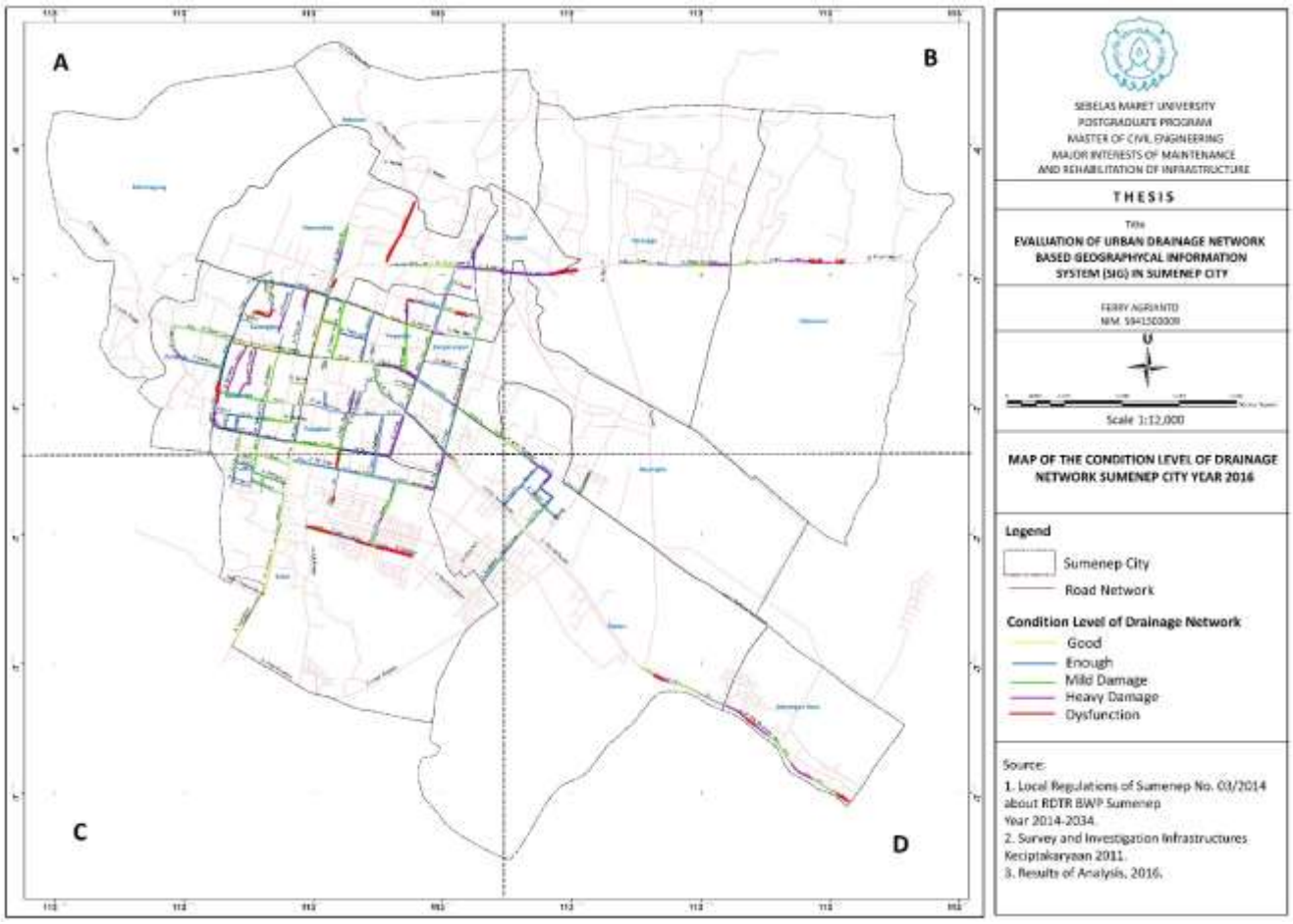

Figure 1. Map of The Condition Level of Drainage Network in Sumenep City Year 2016

4. Conclusion

The value of each segment condition of drainage network in Sumenep vary according to the aspect of the sedimentation and completeness of infrastructure and facilities that demonstrate the level of condition, namely: good, enough, mild damage, heavy damage and dysfunction. Drainage network segment considered good if the network is functioning between 76%-100%, segments categorized sufficient drainage network when the network is functioning between 51%-75%, segments categorized mildly damaged drainage network when the network is functioning between 26%-50%, segment drainage network categorized as severely damaged if the network is functioning between 1%-25%, and joint dysfunction are categorized drainage network if the network can not be enabled or 0%. In each segment of the drainage network can also be determined the type of maintenance action recommendations are: routine maintenance, periodic maintenance, rehabilitation and design study which is strongly associated with the level of drainage network link conditions.

ArcGIS applications can be used as a computer-based tools in the process of evaluating the condition of the drainage network. This is done by integrating or combining the results table level assessment of drainage network link conditions with a layer of drainage network maps using the join function and relates to the application. Results of the integration in the form of drainage network map Sumenep 2016, a map of the type of building drainage network Sumenep 2016, a map of the level of drainage network conditions Sumenep 2016 and map recommendations drainage network maintenance actions Sumenep Year 2016. In addition, ArcGIS applications can do the selection of appropriate specific criteria so by using the function select by attributes can know the number of locations along the drainage network segments according to the level of condition. From the analysis of selected segments of drainage network according to the level of the conditions obtained are of a total 428 network there are 43 sections belonging to the state level "Good", 198 network belong to the state level "Enough", 115 network belong to the state of "Mild Damaged", 50 sections belonging to the state" Heavy Damage "and 22 network belong to the state of "Dysfunction".

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