Evaluation of Drainage Channel on Meteorological Road, Laut Dendang Village, Deli Serdang Regency

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Abstract

Drainage is one way of removing unwanted excess water in an area and dealing with the effects of excess water in the system. When the rainy season comes, there are almost floods or puddles on urban roads. The large population also makes the volume of drainage channels fill up quickly, while the drainage capacity tends to decrease due to rainwater (erosion) and sedimentation. Meteorological Street, Laut Dendang Village, Percut Sei Tuan sub-district, Deli Serdang Regency, is one of the villages that is frequently flooded every time it rains. On these issues, the researcher highlights the importance of evaluating the Deli Serdang Regency's drainage system along Meteorological Road to anticipate when the rainy season comes. The general exponential method can determine whether the existing drainage volume can still accommodate terrestrial run-off and domestic wastewater in the next 30 years and calculate the population growth. Based on the research results from rainfall data obtained from Meteorology Road, the rainfall intensity value for the last ten years (2010 - 2019) was 10.538 mm/day. Thus, the amount of discharge flowing in the drainage channel ($Qplans_{ning}$) is equal to 0.832 m^3/sec, while the planned Q for the next ten years is 0.874 m^3/sec, for the next 20 years is 0.953 m^3/sec, and 30 years into the future. front is 1.111 m^3/sec. Based on the calculation results, Qplans exceeds Qeksisting. Therefore, a new channel plan is needed.

Keywords: Evaluation, Domestic Wastewater, Rain Intensity, Drainage Plan.

INTRODUCTION

An

Introduction

Deli Serdang is a district in the province of North Sumatera, has a population of 1,931,441 people (BPS, 2021) and a land area of 2,498 km² (BPS, 2015). Due to transmigration and urbanization, the district has developed rapidly in the last decades. The population of Deli Serdang district has increased by almost 570 thousand people, or an average increase of 45 thousand per year compared to data from 2010 until now. Based on population projections, it is predicted that the population of Deli Serdang will continue to increase even until 2030. The population density of 879.09 people/km² is enormous compared to Indonesia's average population density, which is only 161 people/km^2. The population in Deli Serdang Regency from 2002 to 2017 continues to increase yearly. The highest increase in population was in 2015, with a total of 2,079,308 people or an increase of around 84,710 people from 2014, and in 2017 the population of Deli Serdang Regency reached 2,114,627 people (Ariani, 2019). With an increase in population, the level of infrastructure development has increased. It has resulted in reduced vegetation cover and changes in the behavior and function of surface water, causing changes in the hydrological cycle, namely decreasing base flow, and increasing surface runoff. It can cause an imbalance in the water system, resulting in flooding and inundation in the downstream areas (Lukman et al., 2018).

Drainage channels are one of the bases for meeting community needs which are the essential components in a city's infrastructure planning. Drainage also aims to make city infrastructure safe, comfortable, clean, and healthy (Lourin, 2019). A well-organized residential area must also be followed by structuring a drainage system that functions to reduce or remove excess water from a site or land so that it does not cause stagnant water that can disrupt community activities (Fairizi, 2015). Providing adequate and integrated drainage channels in an urban drainage system is necessary. Most cities in Indonesia, including Deli Serdang Regency, design drainage to drain rainwater into water bodies (runoff) as quickly as possible. The large population makes the volume of drainage canals fill soon, while the drainage capacity tends to decrease due to rainwater (erosion) and sedimentation. Meteorologi Street, Laut Dendang Village, Percut Sei Tuan sub-district, Deli Serdang Regency, is one of the villages that is frequently flooded every time it rains. Adult calf-deep floods often occur because only one side of the ditch holds water (Septriana et al., 2020). In 2017, according to the records of the Sampali Climatology Station, there were an average of 16.17 or 16-17 rainy days with an average rainfall volume of 179.42 mm. The most significant rainfall occurs in September, 322 mm, while the minor precipitation occurs in February, 21 mm.

Researchers highlight the importance of evaluating the drainage system in Deli Serdang Regency, namely along the Meteorological Road, for the next 30 years to anticipate when the rainy season comes. Whether the existing drainage volume can accommodate terrestrial runoff and domestic wastewater can be known. To formulate appropriate technology as a flood/inundation management strategy. This study uses a general method that is often used, which aims to calculate population growth and evaluate the suitability of the discharge capacity of the drainage canal with the planned conditions and factors that influence the occurrence of flooding in the drainage canal and efforts to reduce the negative impact with a drainage field planning that is integrated so that it can become a planning guide for the development of facilities and infrastructure in Laut Dendang Village. Some researchers have researched the evaluation of urban systems, namely Ikhwali et al. (2022); Pasaribu et al. (2022); Luthan et al. (2022); Prayogo et al. (2023), but none of these researchers have studied predictions of flood discharge for the next 10-30 years. No published article in Indonesia predicts future flood events by considering population growth, especially those that make Deli Serdang Regency a sizeable natural resource.

Material and Method

Location

This research was conducted on Meteorology Road (along 1 km), Laut Dendang Village, Deli Serdang District, North Sumatera. The research object is close to Medan State University and the Medan Hajj General Hospital. The location plan can be seen in Figure 1.

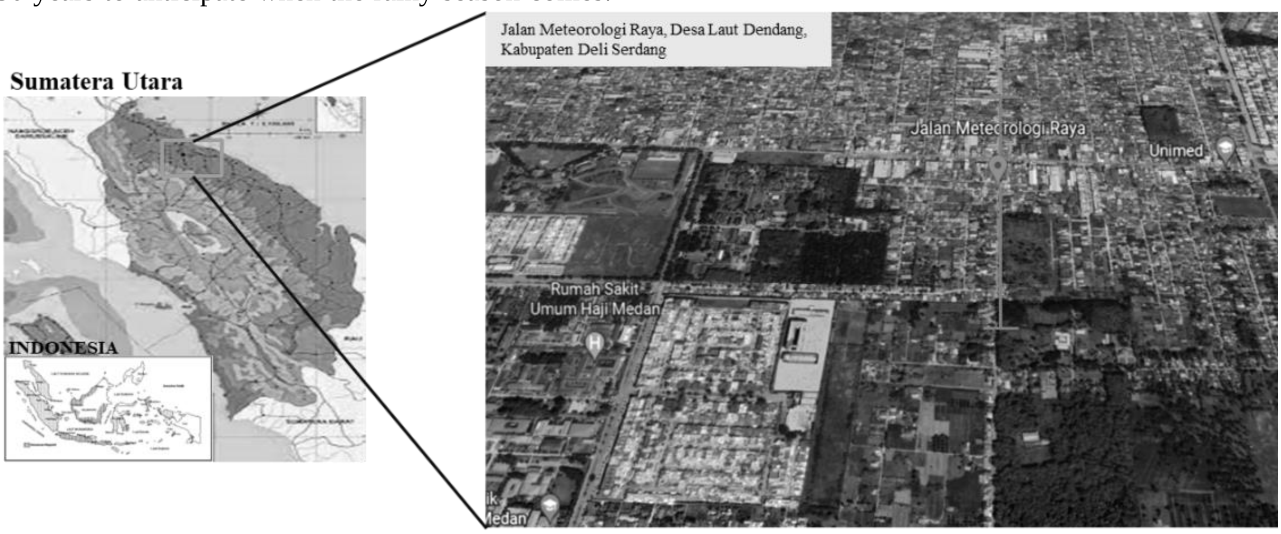

Figure 1. Meteorology Road-Site Map

Collecting Data

Data collection includes primary data and secary data. Preliminary data were obtained from the field in the form of data measuring the drainage channel's dimensions and the drainage channel's dimensions. Secary data is in the form of rainfall data obtained from BMKG and population data obtained from the local village head office.

Data Processing and Drainage Analysis

After getting the drainage channel dimension data, rainfall data, and population data, an analysis can be carried out. The drainage channels and the data obtained are analyzed and evaluated to determine whether they can work properly in the next 10, 20, and 30 years as the population grows. To analyze the population growth rate, the exponential method using equation (1).

$$P_t = P_o e^{rt}, \text{ where } r = \frac{1}{t} \ln \left[\frac{P_t}{P_0}\right] \quad (1)$$

Information:

P_t = Population in t-year (previous year)

P_0 = Total population in the base year

r = Population growth rate

t = The time between the base year and t-year

e = The principal number of the natural logarithmic system (Ln) is 2.7182818

Rain intensity analysis from data obtained from BMKG with the following equation (2).

$$I = \left(\frac{R24}{24}\right)\left(\frac{24}{t}\right)^{\frac{2}{3}} \quad (2)$$

Information:

I = Rain intensity (mm/hour)

t = Duration of rain (hours)

R_{24} = Daily Maximum Rainfall (mm)

The frequency distribution with the Gumbel method was analyzed by sorting the rainfall data obtained from the Dendang Marine Meteorological Station from the highest to the lowest. This method uses extreme values in the analysis process, which will be searched for several return periods. After obtaining the average maximum rainfall value, determine the standard deviation, which can be calculated using the equation (3).

$$S_X = \sqrt{\frac{\sum(X-X)^2}{n-1}} \quad (3)$$

Information:

S_X = Deviation standard

X = Maximum rainfall (in Table 5)

n = Number of samples

Result and Discussion

Existing Drainage Volume

This research was conducted on the outskirts of 1 km right side of Meteorology Road in Hamlet IV, Laut Dendang Village. Therefore, we obtained data on the population around the object of research (Dusun IV) from the Laut Dendang Village Office as shown in Table 1.

Table 1. Population on Meteorology Road

Data	Amount
Total population	1841
Number of families	405
Number of average population/house	5

Drainage channel specifications data were obtained by direct observation and measurement, and drainage channel specifications were obtained on Meteorology Road is as follows and can be seen in Figure 2. Drainage channel length (p): 1.000 m, drainage channel width (l): 94 cm, drainage height (t): 48 cm, water level (ta): 9 cm, sedimentation height (ts): 3 cm.

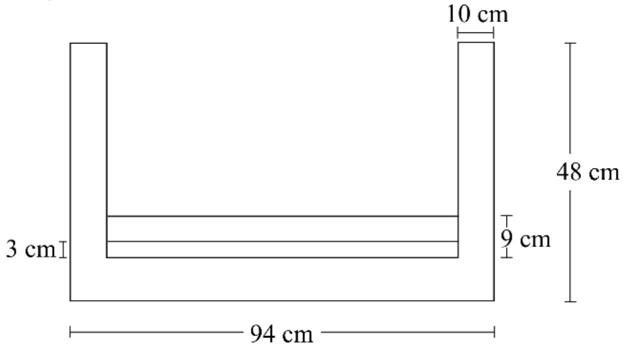

Figure 2. Drainage Channel Dimensional

Drainage channel maximum volume:

$V = 0.94 \text{ m} \times 0.38 \text{ m} \times 1000 \text{ m} = 357 \text{ m}^3$

The drainage channel is only able to accommodate a maximum volume of 357 m^3.

Sedimentation volume:

$V = 0.94\text{ m} \times 0.3\text{ m} \times 1000\text{ m} = 28.2\text{ m}^3$

Finding Volume on a Channel at a Specific Point Throughout 200 m.

$V = 0.94\text{ m} \times 0.9\text{ m} \times 200\text{ m} = 16.9\text{ m}^3$

Calculating the Amount of Domestic Wastewater

1. Production of domestic wastewater

Assuming water use is 120 L/person/day. It is known that the population in Table 1 is 1841 people with an average population of 5 people/family.

Total Wastewater $= 80\% \times 5 \times 120$ L = 480/day

So, the amount of domestic wastewater production is 480 m^3/day, 20 m^3/hour, 0.3 m^3/minute, 0,005 m^3/sec.

2. Population Growth Rate

Using the exponential method

$P_t = P_o e^{rt}$ with $r = \frac{1}{t} \ln \left[\frac{P_t}{P_0}\right]$

The population in the base year (2021) is 1841, and the population in the previous year (2020) is 1811.

Population growth rate $r = \frac{1}{1} \ln \left[\frac{1811}{1841}\right] = 1{,}6\%$

The population growth rate is 1.6% per year.

3. Population in the next 10, 20, 30 years

$P_t = P_o e^{rt}$

$P_{10} = 1841 \times 2.7182818^{(0,15)(10)} = 2163$

$P_{20} = 1841 \times 2.7182818^{(0,15)(20)} = 2848$

$P_{30} = 1841 \times 2.7182818^{(0,15)(30)} = 4787$

So the population in the 10th year is 2163 people/427 families, in the 20th year 2848 people/497 families, in the 30th year 4787 people/957 families.

4. Discharge of domestic wastewater produced in the next 10, 20, 30 years

$\text{10th year} = 427\text{ houses} \times 480\text{ m}^3$
$= 204.960\text{ m}^3$

$\text{20th year} = 497\text{ houses} \times 480\text{ m}^3$
$= 238.560\text{ m}^3$

$\text{30th year} = 957\text{ houses} \times 480\text{ m}^3$
$= 459.360\text{ m}^3$

Calculating Excess Water

1. Rainfall intensity

Table 2. Rainfall Data for The Last 10 Years from The Laut Dendang BMKG

Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Ags**	**Sep**	**Oct**	**Nov**	**Des**
2010	71	48	401	24	20	47	69	48	40	41	66	80
2011	78	35	64	64	39	40	54	98	59	58	63	60
2012	40	50	42	57	83	65	65	46	60	75	60	33
2013	29	66	53	63	27	39	58	33	32	70	21	111
2014	20	22	35	31	46	49	34	91	66	41	57	165
2015	42	46	10	12	39	11	86	50	52	76	90	43
2016	23	71	9	9	40	41	49	54	84	47	57	34
2017	37	6	40	44	32	64	32	82	34	84	65	135
2018	29	40	18	68	35	42	62	33	56	147	76	106
2019	66	25	17	135	364	81	95	130	343	291	205	140

Based on the BMKG rainfall data in Table 2, the maximum rainfall data is obtained in Table 3.

Table 3. Maximum Rainfall

Year	**Month**	**Rainfall (mm)**
2010	December	80
2011	January	78
2012	May	83
2013	December	111
2014	December	165
2015	November	90
2016	September	84

2017	December	135
2018	October	147
2019	September	343
Total		3769.5
Maximum		343
Minimun		78
Average		131.6

2. Rainfall intensity analysis

Based on Tables 2 and 3, it is found that the maximum daily rainfall is 80 mm.

$$I = (\frac{80}{24})(\frac{24}{60})^{\frac{2}{3}} = 0.192 \text{ mm}$$

From the calculation above, the rain intensity is 0.192 mm/day. After that, an analysis of the frequency distribution was carried out using the Gumbel method. The investigation was carried out by sorting the rainfall data obtained from the highest to the lowest. This method uses extreme values in the analysis process to search for several return periods, namely 10, 20, and 30 years. The results of calculating the frequency distribution with the Gumbel method can be seen in Table 4.

Tabel 4. Maximum Rainfall

M	X (mm)	X^2 (mm)
1	343	117649
2	165	27225
3	147	21609
4	135	18225
5	111	12321
6	90	8100
7	84	7056
8	43	6889
9	80	6400
10	78	6084
n = 10	$\sum X$=1316 mm	$\sum X^2$=231558

Information:

M = Notation of the order of magnitude of rainfall

n = Number of years

X = Maximum rainfall

From the calculation results, it is obtained that the average maximum rainfall is 1316, Then determine the standard deviation. Looking for the value of S_x, the maximum rainfall calculation is performed from the rainfall data obtained. Then the maximum rainfall data is obtained in Table 5.

Table 5. Nilai Y_n dan S_n

No	Year	X	(X-X)	$(X\text{-}X)^2$
1	2010	343	211.4	44689.96
2	2011	165	33.4	1115.56
3	2012	147	15.4	237.16
4	2013	135	3.4	11.56
5	2014	111	-20.6	424.36
6	2015	90	-41.6	1730.56
7	2016	84	-47.6	2265.76
8	2017	43	-48.6	2361.96
9	2018	80	-51.6	2662.56
10	2019	78	-53.6	2872.96
n = 10		1316 mm		58372.4
X		131.6 mm		
Yn		0.4952	Sn	0.9496

Yn and Sn values were obtained from the Gumbel method frequency table in the previous discussion, which was seen based on the number of samples (n). based on the table above, it is known that n = 10, then the value of Yb is 0.4952, as well as the value of Sn, which is determined through the price table of Sn, which is based on the value of n = 10, then the obtained Sn is 0.9496. After obtaining the average maximum rainfall data, the next step is determining the Sx value.

$$S_X = \sqrt{\frac{58372{,}4}{10-1}} = 80{,}53 \text{ mm}$$

Then the Sx value is 80.53 mm. To determine the amount of rainfall for the T year return period, it is necessary to pay attention to the relationship between the T year return period and the Yt (reduced variate) value. This relationship can be seen in Table 6.

Table 6. Y_t Calculation

t-Period (Year)	Y_t	t-Period (Year)	Y_t
2	0.3668	25	3.1993
5	1.5004	50	3.9028
10	2.2510	75	4.3117
20	2.9709	100	4.6012

In determining the extreme value of rain intensity, the t-year return period will be used. In this study the extreme values of rainfall intensity to be sought are for return periods of 10, 20 and 30 years.

10th year: $X_t = 131.6 + \frac{2.2510-0.4952}{0.9496}(80.53) = 280.5$ mm

20th year: $X_t = 131.6 + \frac{2.9709-0.5236}{1.0628}(80.53) = 317.035$ mm

30th year: $X_t = 131.6 + \frac{3.34-0.5362}{1.1124}(80.53) = 334.575$ mm

Based on the calculation above, the data for obtaining the extreme value of the return period rainfall is obtained in Table 7.

Table 7. Xt Calculation

t-Period (Year)	Yt	Yn	Sn	Xt (mm)
10	2.2510	0.4952	0.9496	280.5
20	2.9709	0.5236	1.0628	317.035
30	3.34	0.5362	1.1124	334.575

Furthermore, analyzing the frequency distribution using the Pearson Log III method is carried out by converting the rainfall data from the Meteorological Station into logarithmic form. Then from the results of these calculations, the average value is sought, then determine the standard deviation value shown in Table 8.

Table 8. $(\text{Log Xi-LogX})^3$ Calculation

Year	Maximum Daily Rainfall (Xi) (mm)	Log Xi (mm)	$(\text{Log Xi-LogX})^2$ (mm)	$(\text{Log Xi-LogX})^3$ (mm)
2010	80	1.903	0.027477596	-0.004554787
2011	78	1.892	0.031243765	-0.005522619
2012	83	1.919	0.022432721	-0.003359874
2013	111	2.045	0.000553693	-1.30288E-05
2014	165	2.217	0.022090961	0.003283386
2015	90	1.954	0.013135716	-0.0015055
2016	84	1.924	0.02090175	-0.003021858
2017	135	2.130	0.003779803	0.000232383
2018	147	2.167	0.009695095	0.000954615
2019	343	2.535	0.217566701	0.101481911
Total		2068853662	0.368877802	0.087974629
Average (X)		2.068853662	0.03688778	0.008797463

Based on the data in the table above, it can be calculated to find the standard deviation value.

$$S = \sqrt{\frac{\sum_{i=1}^{n}(\text{logX1} - \text{Log X})^2}{n-1}} = \sqrt{\frac{0.368877802}{10-1}} = 0.202451037$$

The value of Cs can be calculated using the equation below:

$$Cs = \frac{n\sum_{i=1}^{n}(\text{logX1} - \text{Log X})^3}{(n-1)(n-2)(\text{S Log X})^3}$$

$$= \frac{10 \times (0.087974629)}{(10-1)(10-2)(0.202451037)} = 0.0603$$

Based on the Cs value obtained, the sloping value in the planned anniversary period can be seen in the K frequency table for the Pearson III Log distribution using the interpolation formula (Table 9). From the results of the K values obtained based on table 9, it can be calculated to find the planned rain volume (Table 10) and planned channel flowrate (Table 11).

Table 9. Slope Value

Bloated (Cs)	**t-Period (Year)**		
	10	**20**	**30**
0.06	1,287	1,609	1,833

Tabel 10. Planned Rainfall Volume

Period	**Average Log Xi**	**Sd (mm)**	**Cs**	**K**	**Log Rr**	**Rr (mm)**	**I (mm/h)**
10	2.068	80.53	0.0603	1.28	2.326	211.83	5.09
20	2.068	80.53	0.0603	1.609	2.4	231.18	5.55
30	2.068	80.53	0.0603	1.833	2.43	269.15	6.47

Table 11. Planned Channel Flowrate

Year	**Coefficient**	**C**	**I (mm/h)**	**A (ha)**	**Q (m^3/sec)**
10			5.09	0.65	0.87377485
20	0.278	0.95	5.55	0.65	0.95274075
30			5.55	0.65	1.110966325

Drainage Channel Dimensional Analysis

Cross-sectional area (A):

A = (b) (p) = (0.94 m) (1000 m) = 0.94 ha

Wet Roving (P):

P = b + 2h = 0.94 m + 2 x 0.48 m = 1.86 m^2

Hydraulic (R):

$$R = \frac{b.h}{b+2h} = \frac{0.45\ m^2}{1.86\ m^2} = 0.24\ m^2$$

Velocity (V):

$$V = \frac{1}{n}.R^{\frac{2}{3}}.S^{\frac{1}{2}} = \frac{1}{0.015}x0.24^{\frac{2}{3}}\ x\ 0.032 = 0.866\ m^3/sec$$

Flowrate (Q):

Q = A.V = (0.94) (0.866) = 0.832 m^3/sec

Table 12. Comparison of Qplans and $Q_{Existing}$

Q Existing Channel (m^3/sec)	**Qplans (m^3/sec)**			**Information**
	10	20	30	
0.832	0.87377485	0.95274075	1.110966325	Not safe for the next 10, 20 and 30 years

Calculation of Planned Drainage Channels

Based on the calculations, Qplans exceed $Q_{existing}$, and a channel plan is needed that can accommodate Qplans, while the price of the manning coefficient is 0.015, and the slope of the bottom of the channel is assumed to be L=1000. Based on the Manning Equation, then:

$$Q = b \times h \frac{1}{0.015}.\left(\frac{h}{2}\right)^{\frac{2}{3}}.\frac{1}{1000}^{\frac{1}{2}}$$

$$0.832 = 2h \times h \frac{1}{0.015}.\left(\frac{h}{2}\right)^{\frac{2}{3}}.\frac{1}{1000}^{\frac{1}{2}}$$

$h = 0.65$ m

Based on the H value above, the b value can be calculated using the following equation:

$b = 2h$

$b = 2 \times 0.65 = 1.3$ m

So, the dimensions of the planned drainage channel to accommodate the Q plan are 0.6 m x 1.3 m.

Conclusion

Based on the analysis that has been done, it is concluded that the drainage system on Meteorology Road, Laut Dendang Village, is currently still feasible and able to drain the existing water discharge but is not safe for the next 10, 20, and 30 years. From the results of calculating domestic waste based on households or residents' houses, it is found that 480 m^3/day/unit, while for the calculation of the estimated amount of domestic wastewater in the next 10 years is 204.960 m^3, in the next 20 years 238.560 m^3, and in the next 30 years 459.360 m^3. From the results of the calculation of rainfall from the BMKG rainfall data (2010-2019), the total rainfall intensity is 10.53 mm/hour, while the estimated rainfall intensity for the next 10, 20 and 30 years is 5.09 mm/hour, 5.55 mm/hour and 6.47 mm/hour. From the calculation results, the current channel discharge value is 0.832 m3/s, while the Q plans for the next 10, 20, and 30 years are 0.87377485 m^3/s, 0.95274075 m^3/s, and 1.110966325 m^3/s. Based on these results, the current drainage channel needs to be fixed to accommodate the future abundance of water. Therefore, it is planned that the size of the planned drainage canal can be made to anticipate a decrease in the effectiveness of the drainage channel on Meteorology Street in the next 10, 20, and 30 years. It is obtained that the planned drainage canal size is 0.65 m x 1.3 m, capable of accommodating the planned water discharge.

References

Ariani, Y. (2019). Peramalan Jumlah Penduduk Tahun 2018-2022 di Kabupaten Deli Serdang Menggunakan Model Arima.

Fairizi, D. (2015). Analisis Dan Evaluasi Saluran Drainase Pada Kawasan Perumnas Talang Kelapa Di Subdas Lambidaro Kota Palembang. *Jurnal Teknik Sipil dan Lingkungan*, *3*(1), 755-765.

Ikhwali, M. F., Ersa, N. S., Khairi, A., Prayogo, W., & Wesli, W. (2022). Development of Soil & Water Assessment Tool Application In Krueng Aceh Watershed Review. *TERAS JURNAL*, *12*(1), 191-204.

Lourin, L. (2019). Evaluasi Dan Perencanaan Saluran Drainase Kecamatan Teluk Ambon, Kota Ambon (Doctoral dissertation, ITN Malang).

Lukman, A. (2018). Evaluasi Sistem Drainase Di Kecamatan Helvetia Kota Medan. *Buletin Utama Teknik*, *13*(2), 163-174.

Luthan, P. L. A., Prayogo, W., Sitanggang, N., & Yacub, M. (2022). Runoff-Stormwater Management at Ridho Residence Using the Rain Garden. *ABDIMAS: Jurnal Pengabdian Masyarakat*, *5*(2), 2720-2730.

Pasaribu, H. S., Marbun, H. S., Sakinah, N., Panjaitan, N., Arifianingsih, N. N., & Prayogo, W. (2022). Evaluation of an Urban Drainage Channel System on Tuamang Road, Medan. *International Journal of Architecture and Urbanism*, *6*(2), 221-232.

Prayogo, W., Siregar, J. P., Soewondo, P., Nasution, Z., Hanami, Z. A., Ikhwali, M. F., ... & Suryawan, I. W. K. (2023). The Investigation on Mineral Wool Performance as a Potential Filter to Remove TSS in Cikapayang River, East Jawa, Indonesia. *Environment and Natural Resources Journal*, *21*(1), 9-18.

Septriana, F. E., Alnavis, N. B., Gustia, R., Wirawan, R. R., Putri, N. P., Hasibuan, H. S., & Tambunan, R. P. (2020). Dampak Perubahan Penutupan Lahan Terhadap Sistem Hidrologi di Jakarta. *Majalah Ilmiah Globe*, 22(1), 51-58.