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Evaluating Inundation in Urban Drainage Systems in Tamalanrea District Makassar Based Ecodrainase

Rizky Alfidhdha[1] and Nieke Karnaningroem[2]

[1]Sanitation Environmental Master Program Engineering Department, Faculty of Civil and Planning, Sepuluh Nopember Institute of Technology, Indonesia
[2]Sanitation Environmental Engineering Department, Faculty of Civil and Planning, Sepuluh Nopember Institute of Technology, Indonesia

Email : rizkyalfidhdha@gmail.com

Abstract— Makassar City is one of the major cities in Indonesia with a population of approximately 1.7 million inhabitants, which continues to grow and followed the development of urban infrastructure facilities. The development also resulted in adverse effects on the environment, especially for water catchment area turns into a watertight region resulting changes in surface runoff were greater, especially in the rainy season because the drainage coefficient values are increasing as well. The purpose of this study was to analyze the capacity of the capacity of drainage channels in terms of technical aspects, analyze and formulate efforts to address flooding in a drainage channel system environmentally friendly in terms of environmental aspects, and Calculating the cost and benefit the development of the handling of flooding with a drainage channel system environmentally friendly in terms of financial aspects. The results obtained from the analysis of the technical aspects there are 14 of 41 channel capacity is insufficient accommodation capacity, resulting in the analysis of environmental aspects require 867 infiltration wells, and 3.19 rate of Benefit Cost Ratio (BCR).

1. Introduction

Currently the drainage system has become one of the most important urban infrastructure. The quality management of a city can be seen from the quality of the existing drainage system. Good drainage system can liberate the city from puddles. Stagnant water causes the environment dirty and slovenly, become mosquito breeding, and sources of other diseases, which can degrade the quality of the environment and public health. One way of realizing a good drainage system will require a valid network data associated drainage system from upstream to downstream. The existence of a map of the flow of drainage network can facilitate the identification of the interference problem drainage and land-use planning Sustainable drainage (suistanable) and Environmental (Ecology). The drainage system in the district has a primary drainage Tamalanrea with a length of 14.65 km 33.63 km of secondary channels. The water level reaches 50 cm in Tamalanrea and Tamalanrea Jaya village, 150 cm in the village Tamalanrea Beautiful, Kapasa, Parangloe, and Bira with an average time of low tide more than 2 hours. With an area of inundation varied, but the overall total inundation area in District Tamalanrea of 649.7 ha (BPBDs Makassar, 2014). The number of roads that run into puddles in the district as much as 670 road, or about 40% of the roads in 1708 with an area of 375,017.4 m². Now, then the concept of the drainage needs to be changed from the conventional concept (old concept), a principled drain surface water as soon as possible to the body of water, into a new concept of urban drainage environmentally sound principled drain excess water to accommodate and absorb into the body of water. Therefore, the analysis of the environmental aspects is necessary so that the drainage system has the goal of accommodating, soak, drain, and maintain, so that soil water conservation is maintained and can take place continuously and dimensions can be more efficient drainage infrastructure. In addition to technical and environmental analysis, financial analysis needs to be reviewed in this study.

2. Material and Methods

In this study, the method used is descriptive quantitative method to evaluate the condition of existing drainage channels are supported by primary data, the survey results in the determination of alternative ways control inundation accordance with the conditions of research areas. Activities carried out by conducting site surveys, analyze and interpret the data obtained for solutions and solving problems found in the field. Data obtained derived from the information society and institutions.

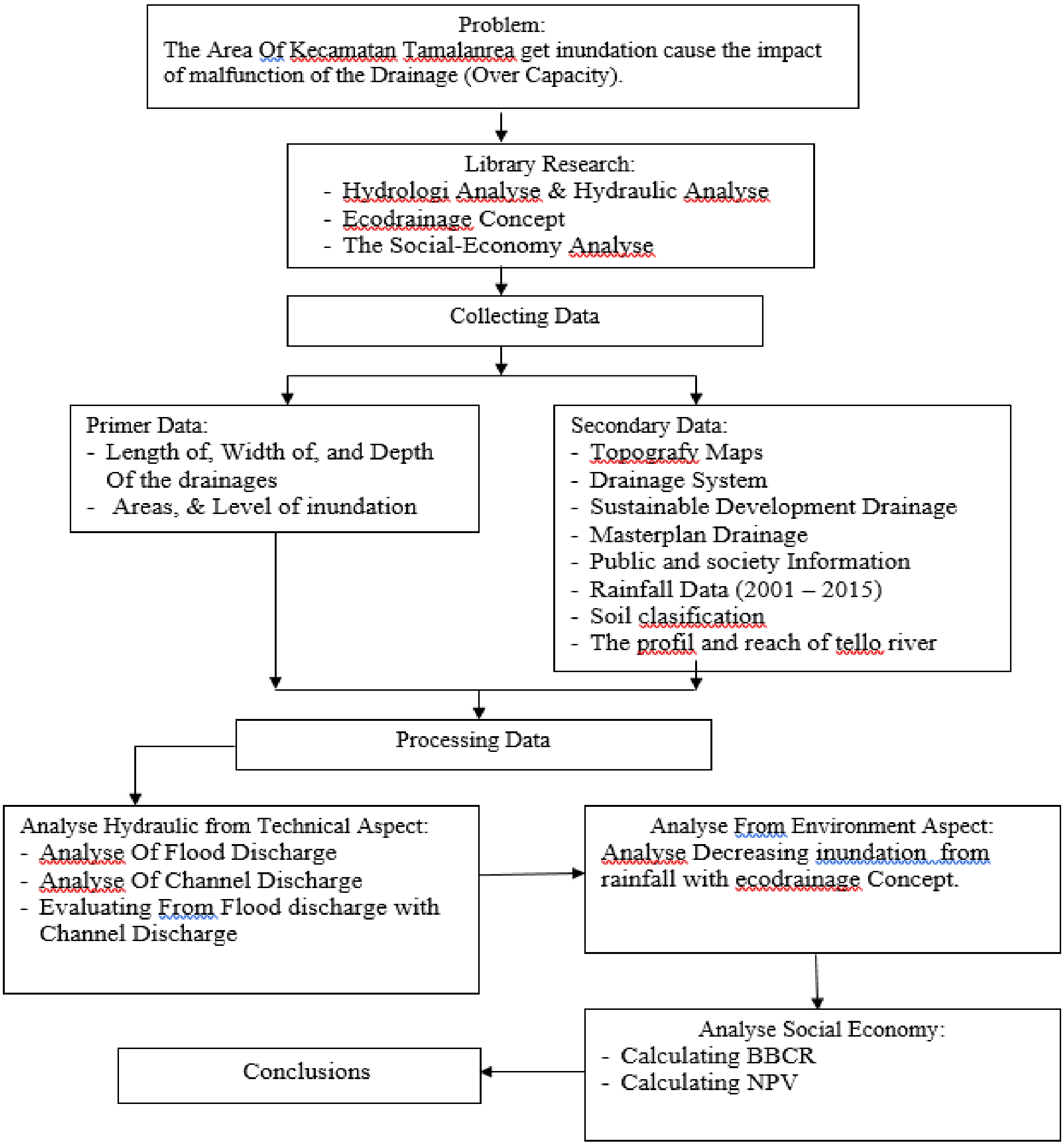

Figure 1. The Flowchart of research step.

3. Result and Discussions

3.1 Technical Aspect

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The technical aspects include: rainfall averages region, analysis of rainfall plan, analysis of the frequency of the maximum daily rainfall (HHM) plan, test the suitability of the distribution, analysis of arch rainfall plans, analysis discharge storm water runoff, water analysis household waste, the analysis of the flow rate channel.

3.1.1. Capacity of Drainage Channels

Hydraulics analysis includes the calculation capacity of the existing channels. Hydraulics analysis calculation is hereinafter used as the basis for the evaluation of the capacity of existing channels. Channel capacity is analyzed to determine the amount of water flow capable drained by the channel cross section. Water discharge capable drained by the channel are affected by such broad dimensions, hydraulic radius and velocity of flow or runoff.

Table 1. The capacity of drainage channel

Channel orientation	Location	L	Shape Of Channel	Dimension			S	m	n	A	P	R	V	Capacity
				b_1	b_2	h								
Secondary	1	870	Trapesium	1	0.7	0.8	0.005	1.25	0.023	0.7	3.56	0.191	4.37	2.972
Secondary	2	120	Trapesium	0.8	0.6	0.6	0.071	1.33	0.023	0.4	2.80	0.150	3.26	1.371
Secondary	3	350	Trapesium	0.6	0.5	0.6	0.034	1.00	0.023	0.3	2.30	0.144	2.19	0.722
Secondary	4	870	Trapesium	0.6	0.5	0.6	0.047	1.00	0.023	0.3	2.30	0.144	2.59	0.855
Secondary	2 ke 4	620	Trapesium	1	0.8	1	0.046	1.00	0.023	0.9	3.83	0.235	3.56	3.205
Secondary	A	800	Trapesium	1.5	1	1	0.024	1.50	0.023	1.3	5.11	0.245	2.65	3.312
Secondary	5	170	Trapesium	1.2	0.6	0.8	0.032	1.50	0.023	0.7	4.08	0.176	2.44	1.759
Secondary	6	180	Trapesium	0.7	0.6	0.6	0.013	1.17	0.023	0.4	2.54	0.153	1.42	0.556
Secondary	7	500	Trapesium	0.8	0.5	0.5	0.006	1.60	0.023	0.3	2.69	0.121	0.84	0.274
Secondary	8	470	Trapesium	0.5	0.4	0.4	0.042	1.25	0.023	0.2	1.78	0.101	1.92	0.346
Secondary	9	340	Trapesium	0.6	0.4	0.4	0.031	1.50	0.023	0.2	2.04	0.098	1.62	0.323
Secondary	10	90	Trapesium	0.5	0.4	0.3	0.037	1.67	0.023	0.1	1.67	0.081	1.57	0.212
Secondary	11	100	Trapesium	0.6	0.5	0.5	0.041	1.20	0.023	0.3	2.16	0.127	2.22	0.610
Secondary	12	650	Trapesium	0.6	0.5	0.5	0.071	1.20	0.023	0.3	2.16	0.127	2.92	0.804
Secondary	13	610	Trapesium	0.3	0.2	0.3	0.061	1.00	0.023	0.1	1.15	0.065	1.74	0.130
Secondary	14	310	Trapesium	1	0.5	0.8	0.029	1.25	0.023	0.6	3.56	0.168	2.25	1.352
Secondary	15	200	Trapesium	0.7	0.5	0.6	0.009	1.17	0.023	0.4	2.54	0.142	1.13	0.407
Secondary	16	1330	Trapesium	1.2	0.8	0.8	0.061	1.50	0.023	0.8	4.08	0.196	3.61	2.886
Secondary	17	720	Trapesium	2	1.5	1.2	0.003	1.67	0.023	2.1	6.94	0.303	1.07	2.253
Secondary	18	210	Trapesium	0.4	0.3	0.5	0.010	0.80	0.023	0.2	1.68	0.104	0.96	0.168
Secondary	19	720	Trapesium	1.2	0.8	0.8	0.009	1.50	0.023	0.8	4.08	0.196	1.40	1.124
Secondary	20	320	Trapesium	0.8	0.5	0.5	0.061	1.60	0.023	0.3	2.69	0.121	2.62	0.851
Secondary	21	310	Trapesium	0.7	0.5	0.5	0.037	1.40	0.023	0.3	2.42	0.124	2.08	0.625
Secondary	22	900	Trapesium	2	1.5	0.8	0.003	2.50	0.023	1.4	6.31	0.222	0.87	1.222
Secondary	23	820	Trapesium	0.6	0.5	0.5	0.010	1.20	0.023	0.3	2.16	0.127	1.10	0.302
Secondary	24	2360	Trapesium	1.5	1.5	2	0.010	0.75	0.023	3.5	7.00	0.500	2.74	9.584
Primary	25	6700	Trapesium	4	3	2	0.010	2.00	0.023	7.0	12.94	0.541	2.89	20.197
Secondary	26	830	Trapesium	0.8	0.6	0.6	0.032	1.33	0.023	0.4	2.80	0.150	2.19	0.921
Secondary	27	510	Trapesium	2	1.2	1	0.031	2.00	0.023	1.6	6.47	0.247	3.00	4.799
Secondary	28	1460	Trapesium	1.8	0.9	1	0.029	1.80	0.023	1.4	5.92	0.228	2.76	3.723
Secondary	29	520	Trapesium	0.7	0.6	0.5	0.003	1.40	0.023	0.3	2.42	0.134	0.62	0.203

Channel orientation	Location	L	Shape Of Channel	Dimension b_1	b_2	h	S	m	n	A	P	R	V	Capacity
Secondary	30	840	Trapesium	0.6	0.5	0.8	0.024	0.75	0.023	0.4	2.60	0.169	2.07	0.911
Secondary	31	2500	Trapesium	1	0.5	0.5	0.024	2.00	0.023	0.4	3.24	0.116	1.61	0.603
Secondary	32	1670	Trapesium	2.5	1.5	1	0.009	2.50	0.023	2.0	7.89	0.254	1.67	3.339
Secondary	33	3940	Trapesium	3	4	2	0.024	1.50	0.023	7.0	10.21	0.686	5.27	36.858
Secondary	34	790	Trapesium	2	1.5	0.8	0.006	2.50	0.023	1.4	6.31	0.222	1.26	1.769
Secondary	35	3000	Trapesium	1.8	0.8	1	0.009	1.80	0.023	1.3	5.92	0.220	1.52	1.972
Secondary	36	2160	Trapesium	1	0.8	0.6	0.010	1.67	0.023	0.5	3.33	0.162	1.29	0.697
Secondary	37	1500	Trapesium	1	0.8	0.6	0.010	1.67	0.023	0.5	3.33	0.162	1.29	0.697
Secondary	38	140	Trapesium	0.5	0.4	0.3	0.010	1.67	0.023	0.1	1.67	0.081	0.81	0.110
Secondary	39	910	Trapesium	1	0.8	0.6	0.029	1.67	0.023	0.5	3.33	0.162	2.20	1.186

3.1.2. Condition of existing drainage

Based on previous calculations that the calculation of the existing channel capacity to discharge the design flood drainage channel conditions at this time can be evaluated. Design flood discharge is the sum of debits that go into the channel. The results of the evaluation will indicate that the channel is still able to function optimally, or is not able to function optimally. Based on the analysis evaluation in District Tamalanrea channel capacity of 41 channels that exist, there are 14 channel capacity is not able to accommodate the design discharge. So as to channel that does not meet the capacities, will be planned one of the technologies that is well catchment ecodrainase for handling.The technically meet the capacities but in the field occurred inundation for trash and sediment that much on the line, so it is necessary for handling channel normalization.

Table 2. The condition of existing drainage

Location	Flood Discharge	Capacity with Sediment	Inundation with Sediment	Requires Capacity > Flood Disc.	Capacity No Sediment	Inundation No Sediment	Requires Capacity > Flood Disc.	Area Of inundation	Height Of inundation	Period of Inundation
	m^3/sec	m^3/sec	m^3/sec		m^3/sec	m^3/sec		m^2	m	Hour
1	1.98	2.23	0.25	Qualify	2.97	1.00	Qualify	-	-	-
2	0.04	1.12	1.08	Qualify	1.37	1.34	Qualify	-	-	-
3	0.54	0.63	0.08	Qualify	0.72	0.18	Qualify	-	-	-
4	1.46	0.68	-0.77	Not Qualify	0.86	-0.60	Not Qualify	32,389.86	0,15-0,20	3
2 to 4	0.64	2.56	1.92	Qualify	3.20	2.57	Qualify	-	-	-
A	3.03	2.32	-0.71	Not Qualify	3.31	0.28	Qualify	-	-	-
5	1.40	1.52	0.11	Qualify	1.76	0.35	Qualify	-	-	-
6	0.77	0.37	-0.40	Not Qualify	0.56	-0.21	Not Qualify	11,579.70	0,15-0,20	3
7	1.37	0.26	-1.11	Not Qualify	0.27	-1.10	Not Qualify	59,226.46	0,15-0,20	3
8	0.36	0.17	-0.18	Not Qualify	0.35	-0.01	Qualify	-	-	-
9	0.39	0.25	-0.14	Not Qualify	0.32	-0.07	Not Qualify	3,773.56	0,15-0,20	3
10	0.45	0.19	-0.26	Not Qualify	0.21	-0.24	Not Qualify	12,761.65	0,15-0,20	3
11	0.10	0.50	0.40	Qualify	0.61	0.51	Qualify	-	-	-
12	0.63	0.66	0.03	Qualify	0.80	0.18	Qualify	-	-	-
13	1.01	0.09	-0.93	Not Qualify	0.13	-0.88	Not Qualify	47,750.19	0,15-0,20	3

Location	Flood Discharge	Capacity with Sediment	Inundation with Sediment	Requires Capacity > Flood Disc.	Capacity No Sediment	Inundation No Sediment	Requires Capacity > Flood Disc.	Area Of inundation	Height Of inundation	Period of Inundation
	m^3/sec	m^3/sec	m^3/sec		m^3/sec	m^3/sec		m^2	m	Hour
14	0.23	1.01	0.78	Qualify	1.35	1.12	Qualify	-	-	-
15	0.05	0.34	0.28	Qualify	0.41	0.35	Qualify	-	-	-
16	1.31	2.16	0.86	Qualify	2.89	1.58	Qualify	-	-	-
17	0.44	1.50	1.06	Qualify	2.25	1.81	Qualify	-	-	-
18	0.19	0.16	-0.03	Not Qualify	0.17	-0.03	Not Qualify	452.98	0,15-0,20	1
19	0.57	0.70	0.14	Qualify	1.12	0.56	Qualify	-	-	-
20	0.05	0.82	0.77	Qualify	0.85	0.81	Qualify	-	-	-
21	0.14	0.50	0.36	Qualify	0.63	0.48	Qualify	-	-	-
22	0.57	0.92	0.34	Qualify	1.22	0.65	Qualify	-	-	-
23	1.14	0.24	-0.90	Not Qualify	0.30	-0.84	Not Qualify	30,173.33	0,15-0,20	2
24	9.87	6.57	-3.29	Not Qualify	9.58	-0.28	Qualify	-	-	-
25	20.95	16.16	-4.79	Not Qualify	20.20	-0.75	Qualify	-	-	-
26	1.61	0.61	-0.99	Not Qualify	0.92	-0.68	Not Qualify	36,961.13	0,15-0,20	3
27	4.73	2.88	-1.85	Not Qualify	4.80	0.07	Qualify	-	-	-
28	1.36	2.98	1.62	Qualify	3.72	2.36	Qualify	-	-	-
29	0.91	0.16	-0.74	Not Qualify	0.20	-0.70	Not Qualify	37,929.79	0,15-0,20	3
30	0.50	0.85	0.35	Qualify	0.91	0.41	Qualify	-	-	-
31	2.25	0.51	-1.74	Not Qualify	0.60	-1.64	Not Qualify	59,128.81	0,25-0,30	3
32	5.94	3.00	-2.93	Not Qualify	3.34	-2.60	Not Qualify	140,217.95	0,35-0,4	6
33	30.56	25.80	-4.76	Not Qualify	36.86	6.29	Qualify	-	-	-
34	0.27	1.33	1.05	Qualify	1.77	1.50	Qualify	-	-	-
35	4.28	1.77	-2.50	Not Qualify	1.97	-2.31	Not Qualify	124,612.45	0,35-0,40	6
36	1.29	0.65	-0.64	Not Qualify	0.70	-0.60	Not Qualify	32,138.73	0,15-0,20	3
37	0.54	0.64	0.10	Qualify	0.70	0.16	Qualify	-	-	-
38	0.07	0.08	0.01	Qualify	0.11	0.04	Qualify	-	-	-
39	1.23	0.99	-0.24	Not Qualify	1.19	-0.04	Qualify	-	-	-

3.2 Environmental Aspect

Alternative inundation reduction referred to in this research is the need for change in the concept of conventional drainage systems become environmentally friendly drainage system in this study is the use of Infiltration wells.

Table 3. The condition of existing drainage

Channel	Location	Type Of Infiltration Well	Inundation (m3/sec)	A (km2)	I	C	Recharge (m3/sec)	Quantity Housing Infiltration wells	Quantity Road Infiltration wells
Secondary	4	Housing	-0.60	0.00048	223.59	0.65	0.01939	31	
Secondary	6	Road	-0.21	0.00050	224.69	0.56	0.01749		12
Secondary	7	Road	-1.10	0.00050	222.52	0.41	0.01268		86
Secondary	9	Housing	-0.07	0.00048	224.41	0.42	0.01258	6	
Secondary	10	Housing	-0.24	0.00048	225.24	0.45	0.01343	18	
Secondary	13	Housing	-0.88	0.00048	223.97	0.44	0.01315	67	
Secondary	18	Housing	-0.03	0.00048	224.35	0.62	0.01856	1	
Secondary	23	Housing	-0.84	0.00048	221.80	0.44	0.01302	64	
Secondary	26	Housing	-0.68	0.00048	223.34	0.55	0.01639	42	
Secondary	29	Housing	-0.70	0.00048	221.36	0.49	0.01447	49	
Secondary	31	Housing	-1.64	0.00048	218.72	0.37	0.01077	153	
Secondary	32	Road	-2.60	0.00050	219.51	0.54	0.01648		158
Secondary	35	Road	-2.31	0.00050	215.44	0.51	0.01527		151
Secondary	36	Housing	-0.60	0.00048	217.54	0.53	0.01550	38	
Amount Of Infiltration Wells								468	407

3.3 Economic Aspect

A development activity is said to be economically viable if the cost of the investment (cost) required less than the benefits (benefits) obtained. Gains on drainage activity generally in the form of indirect revenue, for example, loss or reduction in loss due to waterlogging or flooding, environmental improvements, improved public health and aesthetic improvements.

Table 4. The Benefit, and Cost of infiltration wells

Channel	Location	Type Of Infiltration Well	Quantity Housing Infiltration wells	Quantity Road Infiltration wells	Cost Housing Infiltration Wells (Rupiah)	Cost Road Infiltration Wells (Rupiah)	Losses due to flood 5 years period (Rupiah)
Secondary	4	Housing	31		88,149,124.38		188,364,242.40
Secondary	6	Road		12		32,122,742.46	95,555,452.15
Secondary	7	Road		86		226,597,999.24	606,187,637.35
Secondary	9	Housing	6		15,835,193.80		16,041,598.05
Secondary	10	Housing	18		50,133,549.37		163,801,440.45
Secondary	13	Housing	67		191,642,432.65		495,236,725.25
Secondary	18	Housing	1		3,864,162.97		5,422,266.45
Secondary	23	Housing	64		183,428,266.79		184,273,040.45
Secondary	26	Housing	42		119,010,380.62		304,315,418.35
Secondary	29	Housing	49		138,311,010.28		206,394,904.30
Secondary	31	Housing	153		434,641,123.13		665,015,858.80
Secondary	32	Road		158		412,895,579.29	2,366,032,290.45
Secondary	35	Road		151		395,868,155.86	2,044,322,741.15
Secondary	36	Housing	38		109,424,652.98		272,533,562.95
	Amount		468	407	1,334,439,896.98	1,067,484,476.85	7,613,497,178.55

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4. Conclusion

Urban street drainage need of improvement by infiltration wells viewed groundwater conditions of diminishing returns. Based on the analysis technical aspect found that there are 14 channel in Tamalanrea district was not qualify to accommodate wastewater and rainwater. Based on the analysis environmental aspect Infiltration wells absorb water into the soil and also reduce the inundation that occur in urban areas. Diameter 1,0 m, depth of water 4 m and soil permeability 0,00015 m/sec. Discharge of infiltration wells 0,0019 m^3/sec. Based on the analysis inundation treatment with the application of absorption wells in Sub Tamalanrea able to absorb 100% to the total amount of recharge wells as many as 875 pieces. Total costs required to manufacture 875 unit of infiltration wells is IDR 2,401,924,372.00. Based on analysis economic aspect (BCR) benefit cost ratio the result of rate is 3.19 and its mean that feasible to develop.

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