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Management strategy of sustainable urban drainage in Pekanbaru City

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Abstract. The rapid growth of population and development has changes in the land use. A lot of opened land or forest has changed into the settlement or industry. This change had made the power of absorption function becomes low instead the surface run off which results in shorter time water retention so that accumulation of collected rainwater exceeds the existing drainage capacity. The basic concepts of sustainable drainage development is increasing the use of water, minimizing losses, improving and conserving the environment. Drainage management model developed is using *eco drain* approach, which is an integrated and comprehensive approach and incorporates ecological or environmental factors in every drainage management effort. This research aims to (1) analyze the characteristic of physical area, environment condition, economy and social community in Pekanbaru City, (2) analyze other important factors affecting the drainage performance that impacted ecology aspect, economy and social community in Pekanbaru City, (3) design the management strategy of sustainable drainage in Pekanbaru City. This research was carried out in Pekanbaru City. This research was a mixture of quantitative and qualitative research. The research methods used were survey and experiment methods. The method of data collection was done through field surveys, documentation, and questionnaire distribution. In quantitative research the data obtained based on questionnaires that were analyzed statistically. Based on data analysis and evaluation, needed strategies for sustainable drainage management in Pekanbaru City. The results showed that the existing drainage channel was unable to accommodate rainwater runoff discharge where (Qp) is greater than Q-exist. Based on the analysis that has been carried out, the sustainable drainage management strategy in the city of Pekanbaru includes 3 (three) aspects, (1) ecology, (2) social, (3) economy. Ecological aspects include drainage management strategies such as normalization of drainage channels and eco drain. Social aspects include participation and community empowerment that actively supports drainage management. Economic aspects include the participation of stakeholders such as the government and the private sector as well as the community in making efforts to manage and maintain drainage facilities and infrastructure.

1. Introduction

The rapid growth of population and infrastructure has caused changes of land use. The changes of land use from the open area into developed area causes decrease of the flow surface absorption function is increasing, that caused water concentration time) much shorter so the accumulated of collected rainwater is exceed the existing drainage capacity. This condition is often shown by the drainage overload in the city, even in the specific residence, so it becomes puddle or might be happened flood that disturb daily activities (Nurhapni, 2008). Besides, the land use change of forest (open area) into developed area can also increase the erosion.

The other factor that also has important role to the flood causal is society bad habit such as throwing garbage into water, drainage, river and the other riverbank. This behavior that almost becomes culture can also be done by the educated circles, the group that supposed to give example and model. Bad drainage condition is one of the flood causal and puddle in Pekanbaru City. This condition is concerned to be worse because there are lots of broken and non-functional drainage, piled-up garbage in drainage, and less society participation in keeping the drainage and residence area clean (Fajar Ramadhani, 2016).

Pekanbaru City is the capital city of Riau Province with width about 632.26 km^2. The population about 800,000 people (2008) which had increased from 586,000 people (2000). The average population growth is about 4% each year. The number of population is predicted to increase into 1.3 million (2019) and 2 million (2026). The highest population especially in subdistricts in central town (City of Pekanbaru and Sukajadi), and the tendency of total population growth in the new residence area (Tampan, Marpoyan Damai,Tenayan Raya, etc.).

Topographically, Pekanbaru City is located in 5 meters above the sea level. In particular areas, the location is higher than the average height with the slope of 0 to 2% that has no potential flood. However, in fact, when it is raining in protocol road section and some locations always flooded that disturb public activities (Bureau of Statistic Center Pekanbaru City, 2017).

One of the floods causal is because the less-maximum drainage function system in Pekanbaru City. The lack of society awareness in keeping the environment is also affected the drainage condition. A lot of garbage sediment causes the drainage, which has function to drain the rainwater, cannot load the rain discharge each time the rain falls.

The drainage concept that is used earlier in Indonesia (old paradigm) is drainage removal which is removing the excess water (especially rainwater) into the closest water body. The excess water is immediately flowed to the drainage, then to the river and finally to the sea, so it will not cause puddle or flood. The removal concept is still practically done by society until now. In each drainage project, there is some effort to make sewer lane from the puddle to the river by the enough slope to drain the puddle. This kind of drainage removal is kind of drainage that is created before the comprehensive thought is developed, when the puddle problem, flood, drought and environmental damage still considered as local and sectoral problem that can be solved in term of local and sectoral without seeing the water resource and environment condition in the upstream, in the middle, and in the downstream comprehensively.

The conventional construction of the drainage is also one of the environmental damage sources; this is because it creates impact, such as (Suripin, 2004):

a. The enhancement of flood discharge and the depletion of groundwater recharge.
b. Water pollution.
c. Groundwater contamination.
d. Land surface downfall.
e. The reduction of the aesthetic value and environmental health.

By the development of comprehensive thinking also encouraged by the spirit of anticipation, the changes of climate nowadays, then it needs the changes of conventional drainage concept for the environmental friendly drainage or eco-drainage (new paradigm). Drainage concept, rainwater excess is not rapidly removed to the nearest river. But, the rainwater can be loaded in some related location through many ways, so that it can directly use or later, can be used to fill the ground water

conservation, to increase ecosystem and environment quality, and as the medium to decrease puddle and flood.

By the environmental friendly drainage, the possibility of puddle/flood in the related location, flood in downstream also drought in upstream is reduced. It is because most of the rainwater excess is held or absorbed in the upstream, middle stream, and downstream. According to the problem, the sustainable drainage construction basic concept is to increase water usability, minimalize the loss also improve and conserve the environment.

The accumulation between the fault impact in rainwater management and environment awareness gives the idea to improve the strategy of drainage management model, by *eco drain* approach. This approach can be called integralistic approach with the implementation of the effort to do comprehensive and integrated drainage management also includes the ecology/environmental factor in every drainage management efforts. Based on the description above, the writer tries to theme "The Strategy of Sustainable Urban Drainage Management in Pekanbaru City (Case Study of Eco Drain Application in Pekanbaru City)".

This purpose is going to be reached through three steps, they are:

a. Analyze the characteristic of area physical, environment condition, economy, and society social in Pekanbaru;
b. Analyze the important factors that affected drainage performance which is impacted to the aspect of ecology, economy and social in Pekanbaru City;
c. Design the management strategy of sustainable urban drainage in Pekanbaru.

2. Research Method

2.1. Sampling point

The research was done in Pekanbaru City. The location of this research that is taken from the Pekanbaru City Administration Map was located in geographical at coordinate of latitude 0º25´17.139″ - 0º41´18.556″ and 101º19´24.199″ - 101º36´12.511″, from Siak Riverbank Area with width of 588.234 km² (58,823.419 ha). The location of the sample collection is in Rumbai Coast Sub-district and Tampan Sub-district.

2.2. Data collection

The collected data were primary and secondary data. The primary data was taken by:

a) Field observation
b) Documentation
c) Questionnaire

The secondary data was taken by:

a. Administration Map of Tampan and Rumbai Coast Sub-district;
b. Profile of Tampan and Rumbai Coast Sub-district;
c. The data of Bureau of Statistic Center in Pekanbaru City;
d. BMKG of Pekanbaru City;
e. Public Work Service in Pekanbaru City

2.3. Research approach

The research methods used in this research were survey and experiment method. In the survey method, the information gathering technique was by sorting some question list for the respondents. The data that was analyzed was the sample data of the population. Besides, the approach was done by experiment method (field experiment). In this research experiment, the researcher tried to find out the affection of the certain variables to the other variables in the strictly controlled condition.

This research was based on the theoretical basis that related to the problem which were theories related to the urban drainage, planning and evaluation, local government policy and environment economy also responses and factors that affected the urban drainage system.

Then, by those theories, was appointed the variables that related to the problem, next, determine the indicators and was proven in the field through observation, interview and questionnaire to the

respondents. It was going to be analyzed statistically by the aspect of social, environment and economy.

This research was trying to find out accurate solution or model in solving the problem in the field (Problem Solving Research). Then, there will be created a management of sustainable urban drainage model later.

2.4. Data collection technique

The data collection technique was taken by observation and interview through questionnaire to the local society.

2.5. Population technique of sample collection

The sample calculation was calculated based on the population in Tampan and Rumbai Coast Sub-district from the Bureau of Statistic Center data in Pekanbaru. Then the respondent that is calculated could use Taro Yamane formula (Riduwan, 2010)

$$n = \frac{N}{Nd^2 + 1}$$

Description:
n : total sample;
N : total population;
d : precision or fault tolerance limit of sample collection (0,05)

The taken sample was flood prone zone which are 2 sub-districts of 12 sub-districts in Pekanbaru. The sample was presented in this Table 1.

Table 1. Total research population and sample

No	**Sub-district**	**Total Population**		**Total Sample**
1	Tampan	269.062	26.906	40
2	Rumbai Coast	2.516	7.252	40
Total				80

2.6. Data analysis technique

This research was mix method of quantitative and qualitative. In quantitative research, the data that was collected based on the questionnaire was analyzed statistically. From the statistic calculation, SWOT analysis was used to find out the drainage management strategy. Besides, the qualitative data that was taken from the observation also used to find out the management strategy of sustainable urban drainage in Pekanbaru City.

2.6.1. Physical Area Characteristic Analysis, Descriptive and quantitative topographic analysis in Pekanbaru, especially Tampan and Rumbai Coast Sub-district was done to get the topographic, hydrologic, geological condition Figure and drainage condition was the important factor in the general drainage management.

2.6.2. Decreasing Drainage Performance Factor Analysis, This decreasing drainage performance factor analysis was scoped the aspect of environment, social, economy and institutional. This decreasing performance of drainage analysis had the purpose to know if each aspect had impacted the drainage in Pekanbaru City.

2.6.3. Instrument Validity and Reliability Analysis, The good research instrument (questionnaire) has to be valid and reliable (Arikunto, 1993). In finding the instrument validity and reliability, instrument test should be done first (Faisal, 1981).

2.6.3.1. *Validity Test*, Validity test used to measure whether the questionnaire was valid or not. The questionnaire was valid when the question could reveal something that would be measured by the questionnaire. To measure the validity level in this research, it was done the correlation between score in each question to the total score construct. The test determined significance by comparing the value of r calculated to the r table in the degree of freedom = n-k in α = 0,05. When r calculated for each question was positive and greater than r table (correlated item value- total correlation), then the question was valid (Suyoto, 2008).

From the table above, it could be explained that value of r calculated > r table based on significant test 0.05, which meant that the items was valid.

Product Moment Correlation Formula:

$$r_{xy} = \frac{N\Sigma xy_{-(\sum x)}(\sum y)}{\sqrt{(N\Sigma x^2 - (\sum x)^2(N\Sigma y^2 - (\Sigma y)^2)}}$$

Description:

r_{xy} = coefficient between variable x and variable y;
$\sum xy$ = total multiplication variable x and variable y;
$\sum x^2$ = square sum of x value
$\sum y^2$ = square sum of y value
$(\sum x)^2$ = squared total x value
$(\sum y)^2$ = squared total y value

2.6.3.2. *Reliability Test*, The meaning of reliability was the measurement constancy (Walizer, 1987). Sugiharto and Situnjak (2006) stated that reliability led to an understanding that the instrument used in the research to gain information could be trusted as the data collection instrument and able to reveal the real information in the field. Ghozali (2009) stated that reliability was an instrument to measure questionnaire that was an indicator of construct. Questionnaire was considered reliable when the respondent answers toward the statement was consistent or stable continuously. The test reliability referred to the degree of stability, consistency, prediction, and accuracy. The measurement that had high reliability was the measurement that could result reliable data.

According to Masri Singarimbun, reliability was index that showed how far was the measurement instrument could be trusted or reliable. When measurement instrument was used twice – to measure the same phenomenon and the result was consistent, then the measurement instrument was reliable. In other word, reliability showed consistency of measurement instrument for the same phenomenon. Empirically, reliability was shown by number that was called reliability coefficient. The high reliability was shown by r value closer to 1. The general agreement of satisfied enough reliability was when ≥ 0.700.

Instrument reliability test used *Alpha Cronbach* formula because this research instruments were questionnaire and multilevel scale. *Alpha Cronbach* formula was shown as follow:

$$r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum \sigma_t^2}{\sigma_t^2}\right)$$

Description:

r 11 = the reliability
n = total tested question items
∑αt2 = total variants

When the value of alpha > 0.7 it was meant sufficient reliability, while the value of alpha > 0.80 it suggested strong reliability consistence to all reliable item and test. Or, could also stated such as this:

- When alpha > 0.90 it was perfect reliability.

- When alpha between 0.70 – 0.90 it was high reliability.
- When alpha 0.50 – 0.70 it was moderate reliability.
- When alpha < 0.50 it was low reliability.
- When alpha was low, it showed some item was not reliable.

2.6.4. SWOT Analysis, SWOT analysis was strategy technique in evaluating strength, weakness, opportunity and threat that was applied in giving solution toward problem. This analysis was placed the circumstance and condition as the input factors, then classified based on each contribution.
SWOT stood for:

S = Strength (*kekuatan*)
W = Weaknesses (*kelemahan*)
O = Opportunities (*Peluang*)
T = Threats (*hambatan*)

There were 2 main factors that would affect the four basic components in SWOT analysis, they were:

a. Internal Factor, they were Strength and Weaknesses. This internal factor would impacted better in the research when the strength was greater that the weakness.
b. External Factor, they were Opportunities and Threats. This was outer entity factor that not directly involve in the research.

After SWOT analysis, it was done deeper research in evaluating ecological, environmental and social factor to the 3 (three) aspects, they were: (1) Value aspect, present condition factor value compared to the ideal condition; (2) Quality aspect, it was important factor value related to the drainage management execution; (3) Rating aspect, it was society ability to respond the condition.

3. Result and Discussion

Physical area characteristic of Pekanbaru City covers the condition of topography, geology and climate that become the main basic in drainage management system executed.

3.1. Topography

Topographically, Pekanbaru City is located in average height of 5 meter above sea level, only certain regions that located higher than the average height it is in the Sultas Syarif Kasim II Airport with height of 26 meter above the sea level and in the North and East of Pekanbaru City. Topography in Pekanbaru, based on the slope class can be classified into four parts they are plain, sloping to wavy, wavy to bumpy, bumpy to hill area.

3.2. Geology

Based on the Geological Map of Pekanbaru and the surrounding (M.C.G. Clarke, 1982.) by the scale of 1: 250.000, Pekanbaru City is generally form by sediment rock in age of Plistosen – Holosen, also alluvium sediment that the process of sedimentaion is still going until present. Lithostratigraphically, the forming rock that arrange the planning area is divided into four rock units they are mud stone (Tup), sand stone (Qpmi), old alluvium (Qp) and new alluvium (Qh).

Geological structure that is found in Pekanbaru City consists of horizontal fault to Northwest – Southeast, Synclinal and Anticlinal fold of vertical fault to Northeast – Southwest. This geological structures is incuded in the Sumatera fault system, while the horizontal faults are included in the Semangko fault system, it is expected to happen during Middle Miocene. The geological structure with regional scale for example Semangko Fault that directed Northwest – Southeast or in the same direction of Sumatera Island can be an earthquake trigger in the fault.

Generally, the ground condition in Pekanbaru City has carrying strength (T ground) between 0,7 kg/cm^2 - 1 kg/cm^2, except in some location that near the confluent (T ground) between 0,4 kg/cm^2 - 0,6 kg/cm^2. The effective soil depth (*top soil*) is mosty less or same as 50 cm in the middle. The effective soil depth around 50 – 75 cm is found in the South and more 100 cm is found in the North of Pekanbaru City.

3.3. Hidrology

Pekanbaru City, generally, has tropical climate with the temperatures around 34,1º C - 35,6º C and minimum temperature around 20,2º C - 23,0º C. Maximum humidity around 96% - 100%. Minimum humidity around 46% - 62%. In the Table 15 is shown that the rainfall data in Pekanbaru in 2017. The rainfall is around 38,6 - 435,0 mm/year with the season as follow:

• Rain season in January - April and September - December.
• Dry season in May - August

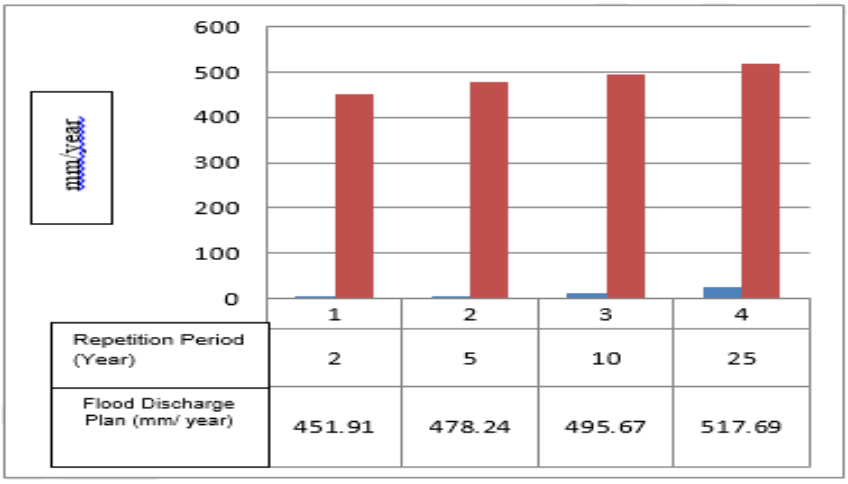
3.3.1. The Condition of Existing Urban Drainage Management System in Pekanbaru City, Drainage system in Pekanbaru City is generally consists of:

a. Water Receiver Body;
b. Primary Channel, the drainage that receive water from the secondary channel and distribute it to the water receiver body;
c. Secondary Channel, the drainage that receive the water from tertiary channel, which receive water from the local drainage and distribute it to secondary channel.

In the outline, urban drainage in Pekanbaru is divided into 4 they are:

a. Macro Drainage
b. Micro Drainage
c. Retention pond
d. Supporting Building

3.3.2. The Factor that Affected Drainage Performance,
3.3.2.1. Meteorological Factor
3.3.2.1.1. Rainfall Distribution



	1	2	3	4
Repetition Period (Year)	2	5	10	25
Flood Discharge Plan (mm/ year)	451.91	478.24	495.67	517.69

Figure 1. Chart of plan flood discharge

3.3.2.1.2. Rain Intensity

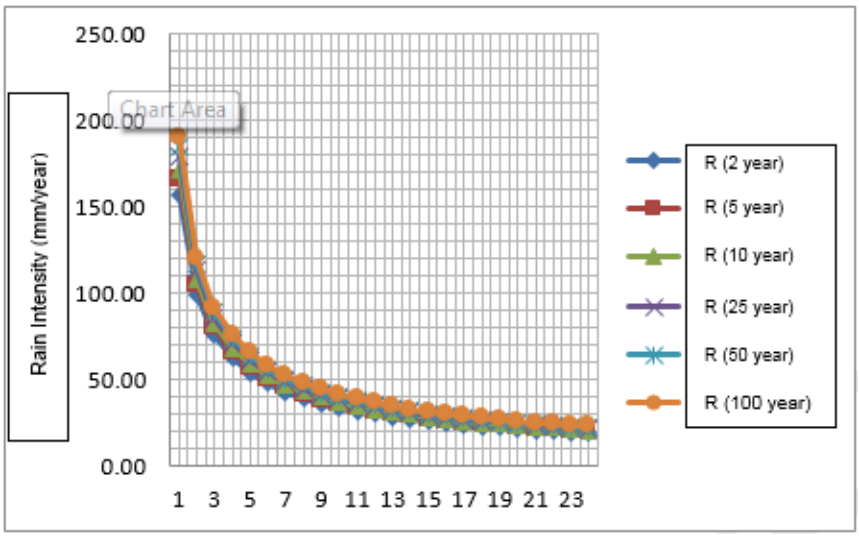


Figure 2. Rain intensity

3.3.2.2. Drainage Discharge Design, based on the calculation in Table 2, it can be concluded that the existing water discharge is not able to accomodate rainwater discharge. This becomes the decreasing performance factor of the drainage.

Table 2. Drainage discharge design calculation

No	Location	Qexisting (m^3/s)	A m^2	Q P (m^3/s)
1	Purwodadi Ujung Teratai Indah Residence, West Sidomulyo	55.83	31.01	999.7
2	Damai Langgeng Residence RW,07, West Sidomulyo	125.06	148.70	4794.0
3	Subrantas Street (*tabek gadang*)	13.70	24.01	774.2
4	Garuda Sakti	84.50	121.43	3914.6
5	Melor Permai Residence RW. 16 West Sidomulyo	4.76	8.76	282.3
6	Nusa Indah Street, New Limbungan	12.28	14.20	457.7
7	Semarang Street, New Limbungan	5.15	12.06	388.8
8	Meranti Pandak Region	9.39	12.72	410.1
9	Harapan Street	22.57	59.90	1931.1
10	Ampera Street, New Limbungan	5.72	5.76	185.6
11	In front of Awal Bros	216.38	818.72	26394.5
12	Karya Sari Street, South Tangkerang	2.19	7.87	253.6
13	Karya Sari Street, South Tangkerang	412.41	2.835.38	91409.7
14	RW. 10 Area, Simpang Tiga Region	107.07	188.20	6.067.4
15	Tengku Bey Street, Simpang Tiga Region	18.49	17.82	574.6
16	Jati Ujung Street	351.75	448.67	14464.6
17	In the side of Harapan Raya Street, Jendral Sudirman Street	9.75	8.95	288.6
18	Surabaya Street	13.34	44.52	1435.4
19	Bersaudara Avenue, North Tangkerang	8.95	46.83	1509.8
20	Banda Aceh Street, Sentosa Street T-junction	1.61	4.95	159.6
21	Kandis Ujung Street, North Tangkerang	4.44	19.90	641.5
22	Kaharudin Nasution Street, Simpang Tiga Region	228.56	311.74	10050.1
23	Witayu Residence, Sri Meranti Region	92.94	151,42	4881.5
24	Citra Palas Residence RW,01, Rumbai Hill Region	919.60	684.75	22075.4

No	Location	Qexisting (m^3/s)	A m^2	Q P (m^3/s)
25	RW, 03 Palas Region	58.76	6.54	1500.4
26	Keli Street I – IX, New Limbungan	21.81	81.90	2640.5
27	BTN Rumbai Lestari Residence, New Limbungan	42.85	244.26	7874.7
28	Coffee Street to Sail River	26.14	22.14	713.7
29	Harmonic Street, New Limbungan	10.58	24.71	796.5
30	RW, 10 Area, New Limbungan	15.92	49.33	1590.3
31	Arifa Teropong Residence, West Sidomulyo	13.02	58.74	1893.7
32	Dolphin Street, South Tangkerang	17.83	118.14	3808.8

3.3.2.3. Riverbank Area Characteristic, the flow and volume of surface stream is greater by the Riverbank Area expansion. The wider the Riverbank Area, the more rainwater needs to be reserved. Siak River is the macro drainage in Pekanbaru that has high water reserve volume. While for the sub-confluent as same as the table above, it has low water reserve volume so the runoff is not distributed all to the sub-riverbank area.

Table 3. Riverbank area width data

No	Riverbank Name	Width (Ha)	Classification
Siak Riverbank Area			
1	Takuana Riverbank Area	5.760	Very Narrow
2	Umban Riverbank Area	5.418	Very Narrow
3	Meranti Riverbank Area	1.657	Very Narrow
4	Limbungan Riverbank Area	5.488	Very Narrow
5	Ukai Riverbank Area	8.112	Very Narrow
6	Lukud Riverbank Area	2.156	Very Narrow
7	Sibam Riverbank Area	2.251	Very Narrow
8	Air Hitam Riverbank Area	3.743	Very Narrow
9	Senapelan Riverbank Area	3.401	Very Narrow
10	Sail Riverbank Area	12.007	Narrow
11	Tenayan Riverbank Area	7.005	Very Narrow
12	Pendanau Riverbank Area	2.921	Very Narrow
	Total Siak Riverbank Area	59.919	Narrow
DAS Kampar			
1	Kelulud Riverbank Area	3.307	Very Narrow
Total		63.226	Narrow

Source: Bureau of Riverbank Area and Social Forestry, 2018

3.3.2.4. Space Management, the shift function of space use especially the green zone has significant impact that when the rain intensity is high, water cannot be absorbed and flowing. Some space shift function in Pekanbaru that has no land substitute is:

a. The building of *Riau Town Square* (Ritos) is located in ex-area of *Purna MTQ* Jenderal Sudirman Street in Pekanbaru. According to space management document, it is included in the protected area that is not for commercial and residence. However, there is power which ignored the rule. So, the building still unclear.
b. Town park in Garuda Sakti Street is converted into local general hospital in Pekanbaru City (RSUD Madani).

Beside those two things, the area use that the function is shifted by the rapid population growth and land demand for trading. This has cause the decreasing of open land that has shifted by the function

into residence and trading. Sporadically rapid infrastructure growth causes some cut off in the drainage and the management is hampered.

3.3.3. Analysis Aspect of Puddle, from Table 4, it is known that the maximum puddle height is 1 meter in Witayu Residence, Sri Meranti Region; Damai Langgeng Residence RW.07 West Sidomulyo dan The end of Purwodadi Teratai Indah Residence, West Sidomulyo. The duration of the puddle lasts for 48 hours in RW.10 Area New Limbungan, Rumbai Coast. Based on those data, the puddle almost spread in all regions in Pekanbaru City which needs maximum management.

Table 4. Puddle/flood classification of location in research location

	Location	**No**	**Puddle width**			
			Height (m)	**Width (ha)**	**Last (hour)**	**Frequency (time/year)**
1	BTN Residence Rumbai Lestari New Limbungan	Rumbai coast	0.5	2	1.5	8
2	Keli I – IX Street New Limbungan	Rumbai coast	0.5	2	1.5	9
3	Semarang Street New Limbungan	Rumbai coast	0.5	0.5	3	15
4	Ampera Street New Limbungan	Rumbai coast	0.4	2	3	10
5	Nusa Indah Street New Limbungan	Rumbai coast	0.6	3	18	6
6	RW.10 Area New Limbungan	Rumbai coast	0.5	3	48	3
7	Meranti Pandak Region	Rumbai coast	0.5	6	24	3
8	Witayu Residence Sri Meranti	Rumbai	1	7	9	5
9	Harmonic Street New Limbungan	Rumbai coast	0.30	2	2	7
10	Harapan Street	Rumbai coast	0.40	1	6	6
11	Citra Palas Residence RW.01 Rumbai Hill	Rumbai	0.40	1	5	3
12	RW.03 Area Palas	Rumbai	0.5	3	3	6
13	Damai Street	Rumbai	0.40	2	2	6
14	Melor Permai Residence RW.16 West Sidomulyo	Tampan	0.80	2	12	8
15	Perumahan Damai Langgeng RW.07 West Sidomulyo	Tampan	1.00	3	14	9
16	Purwodadi Ujung Teratai Indah Residence West Sidomulyo	Tampan	1.00	2	12	7
17	Arifa Teropong Residence West Sidomulyo	Tampan	0.40	2	4	5
18	Subrantas Street (*tabek gadang*)	Tampan	0.30	1	4	8
19	Garuda Sakti Street	Tampan	0.40	1	5	7

Source: Public Work Service,2018

3.3.3.1. *Ecological Aspect Analysis*, based on survey and observation result that is taken from *Bapedda* and Public Work Service of Pekanbaru is described the ecological factor that causes water runoff is:

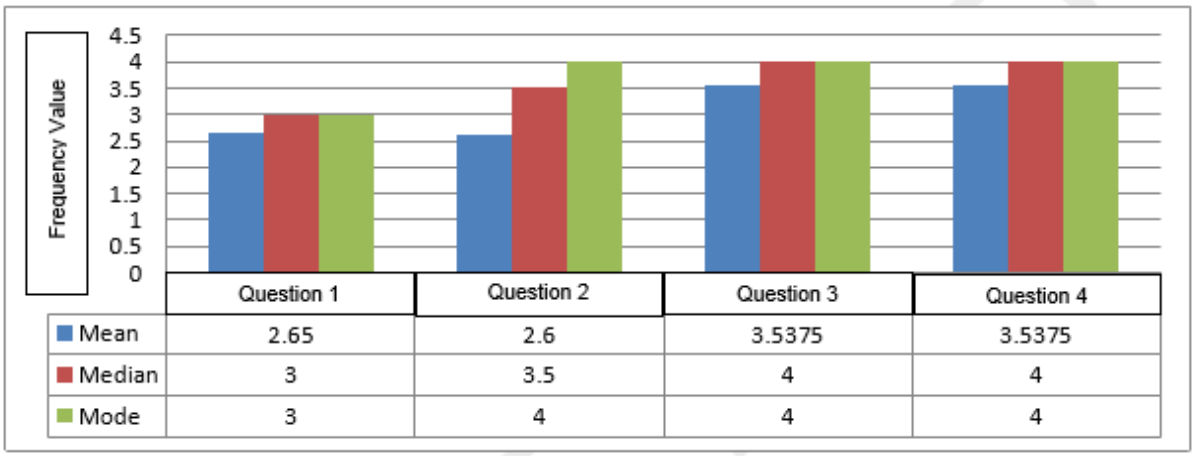
a. Siak River Overflow, Flood that caused by Siak River overflowing is a phenomenon that annually happened. The rise of water face height of Siak River is caused by the sea water tidal (Siak River is overflowed). Some residence environment and activity that is located in north and south of Siak River that is flood prone and puddle, especially Rumbai and Rumbai Rumbai coast (north) and Senapelan, Lima Puluh, Bukit Raya, Tampan. Payung Sekaki, Sukajadi and the City of Pekanbaru (south part). Flood that caused by Siak River overflow is the phenomenon that happen annually. The rise of Siak River water face is caused by the sea tidal (Siak river overflow) and the high rainfall.

b. Existing drainage condition in Pekanbaru City, The high level of vulnerabilty and also less awareness on the flood disaster become the high risk factor toward flood disaster. The greatest risk of flood is by living in the high vulnerability area, which are in the downstream areas with bulding location in the river border. Topographically, this area is considered low with the elevation height around (+1.50 - +2.50) m above the average sea level, and every rain season often flooding.

The present drainage condition is facing some problems that made the drainage cannot flow water runoff, which are:

a. Channel silting caused by sediment (garbage or society water waste);
b. Green zone shifting into business and residence area, that made less absorption area and drainage clog;
c. Development area that is out of RT/RW border;
d. The drainage system has not well managed
e. Many residences located in the basin area;
f. The narrowing of primary channel in the downstream (bottleneck);
g. The Drainage capacity is lower than flood discharge.

3.3.3.2. Social Factor Analysis, flood and puddle problem in Pekanbaru area from social aspect is caused by social factor such as lower society role and participation.



	Question 1	Question 2	Question 3	Question 4
Mean	2.65	2.6	3.5375	3.5375
Median	3	3.5	4	4
Mode	3	4	4	4

Figure 3. Social factor that cause runoff

From Figure 3 it can be explained that the society is tended to not ignore the drainage. This is the reason that causes less well maintenance to the drainage. The questionnaire analysis result shows that the social factor that affected the flood causal is the less society awareness in maintaining the existing drainage.

3.3.3.3. Economical Factor Analysis

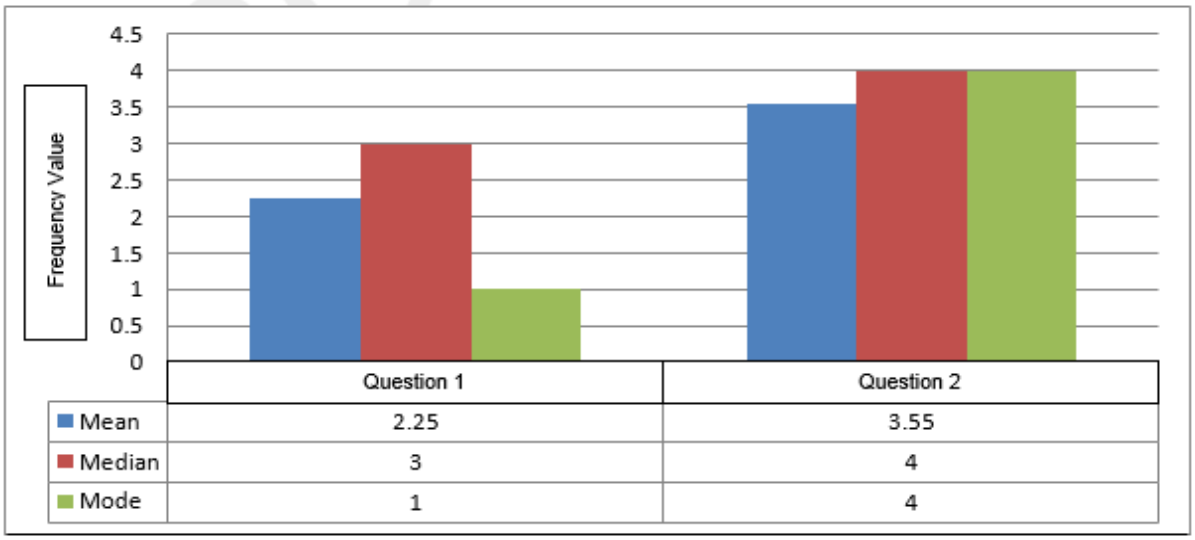


Figure 4. Economical factor that cause runoff

Based on the questionnaire and observation result by Public Work Service of Pekanbaru City, and some information from the locals, it is going to be directly observed, economical factor that affected the flood causal is in the line to the questionnaire result are:

- Drainage construction that is not optimized yet;
- The uneven economic growth.

3.3.4. Management Strategy of Sustainable Drainage in Pekanbaru City

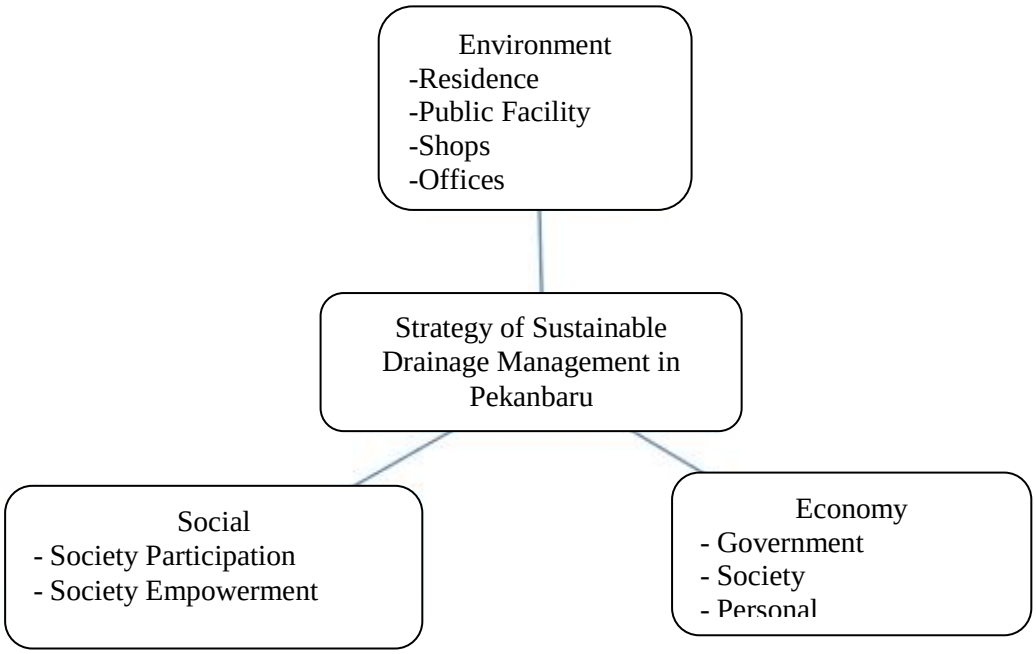


Figure 5. Concept of management strategy of urban drainage in Pekanbaru

Based on the concept of drainage management strategy in Figure 5 it can be described that this strategy consists of 3 (three) aspects which are: (1) environment, (2) social, (3) economy. Those three aspects are the important factor that made the flood/puddle causal in Pekanbaru City. Further

ecological aspect covers the drainage management strategy in the residences, public infrastructures, shops and offices. The social aspect covers the role of society that supports the drainage maintenance. Then, the economical aspect covers the role of the stakeholder such as government and personal also the society in the effort of managing and maintaining the drainage.

3.3.5. Improvement Strategy, based on the puddle causal factor, it can be arranged the alternative strategy based on the explanation in the previous chapter. This strategy is arranged as an alternative in solving drainage problem in Pekanbaru. The strategy arrangement used SWOT analysis by sum up the assessment score in one drainage management strategy improvement with environmental basis, such as the Figure 6 and Table 5.

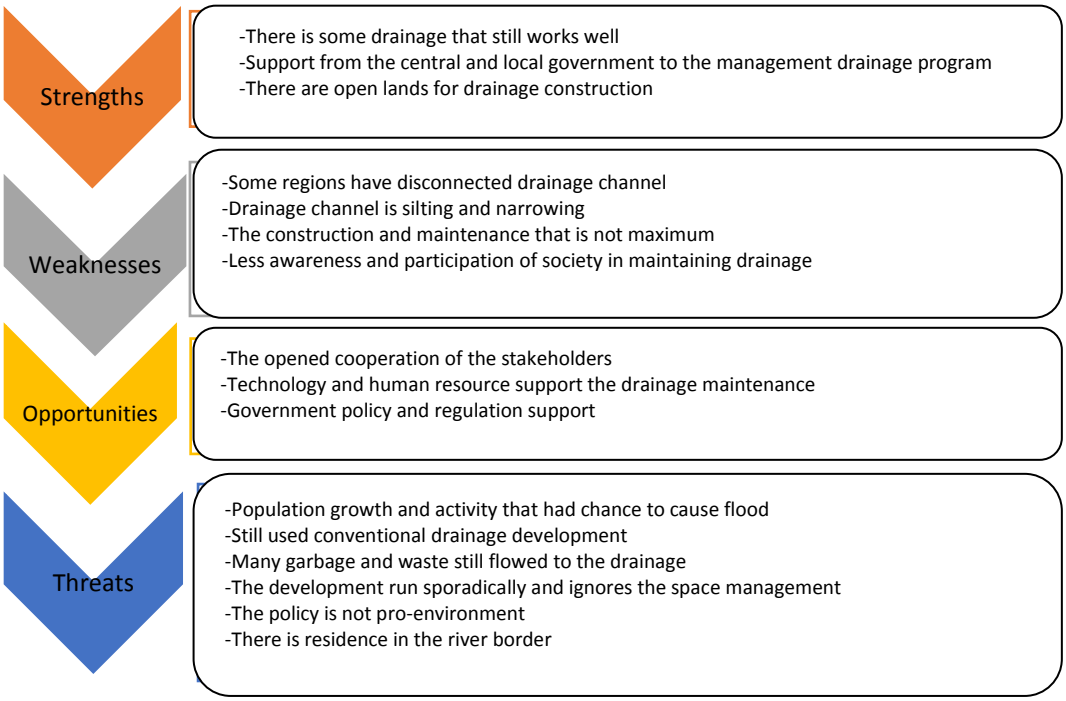


Figure 6. SWOT inventory factor of drainage management in Pekanbaru

3.3.5.1. Environmental Analysis, this environmental analysis covers the drainage improvement in Pekanbaru City on priority scale strategy of SWOT in urban drainage management in Pekanbaru City, which are:

a. Drainage improvement and management in the environmental basis (eco drain);
b. Drainage infrastructure acceleration in improving and constructing;
c. Drainage performance and supporting facility enhancement;
d. Infrastructure development by using the land availability, human resource and IPTEK;
e. Drainage construction as consistent as the SNI planning document;
f. Divided drainage management of rainwater and waste.

Based on the solving priority, it is formulated some concepts/ models that can be used to accommodate drainage management in Pekanbaru City which are:

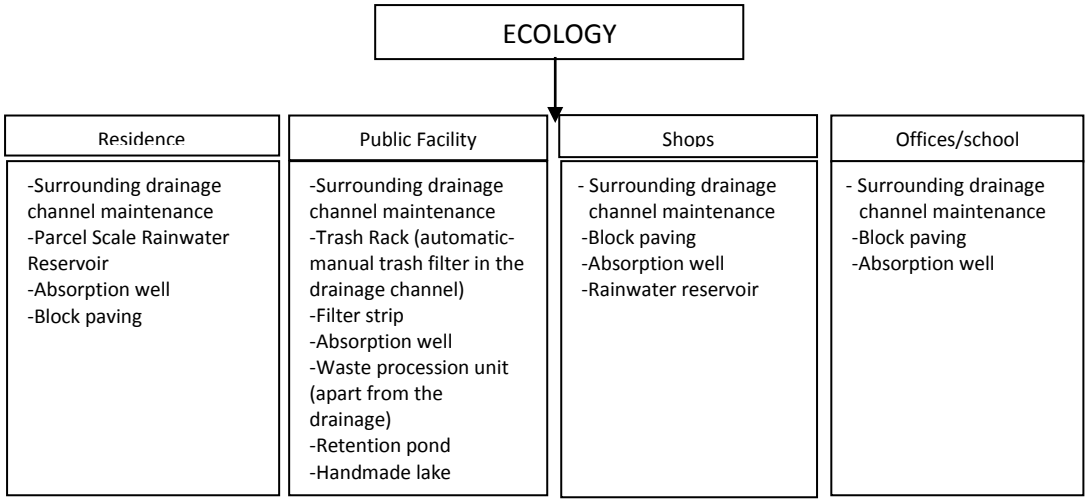


Figure 7. Ecological model and sustainable drainage management

3.3.5.2. Social Analysis. Based on SWOT analysis, solving priority of drainage management in Pekanbaru City from the social aspects are:

a. Society guidance in maintaining the drainage;
b. Government and personal cooperation in drainage management in Pekanbaru;
c. Campaign and socialization of drainage management in the media;
d. Society empowerment and participation in maintaining the drainage

3.3.5.3. Economic Analysis, Based on SWOT analysis, solving priority of drainage management from economical aspects cover:

a. Policy and program synchronization by the capital government, local government and personal in maintaining the drainage;
b. Financial cooperation between government, personal and society

The economic model is focused on financing the existing drainage management and maintenance in Pekanbaru City. Here are the financial concepts on drainage management:

(1) The financing of Urban Drainage is set based on maintenance needs.
(2) The financial kind of Urban Drainage covers:
- information system;
- planning;
- construction execution;
- operation, maintenance; and
- monitoring, evaluating and society empowerment.

(3) The financial source comes from:
- capital, province government, and/or City Government;
- private company; and
- society

3.3.5.4. Institutional Analysis, Based on SWOT analysis, drainage management strategy from the institutional aspect is here as follows:

a. Policy and program synchronization of capital government, local government and personal in drainage management
b. Improving institutional capacity

According to those things, the policy direction that comes from the government of Pekanbaru City in managing the drainage is:

a. Arranging DED Urban Drainage in Pekanbaru City;
b. Land acquisition for reservoir (*embung*);

c. Arranging DED for reservoir;
d. Constructing reservoir;
e. Constructing solid drainage channel.

4. Closing

4.1. Conclusion

From the ;research result, it can be concluded that:

1. The existing drainage channel capacity in the location cannot contain rainwater in 2 years constantly, so it cause puddle in some point in Pekanbaru City when heavy rain happened.
2. The decreasing causal factor of drainage performance in Pekanbaru City covers meteorology, Riverbank Area characteristic and land management.
3. Drainage management strategy from:
   a) environmental aspects are:
   - Drainage construction and management in environmental basis (eco drain);
   - Drainage infrastructure improvement and construction acceleration;
   - Drainage performance and supporting facility improvement;
   - Infrastructure improvement by using the availability
   - Land, human resource and IPTEK;
   - Drainage construction as consistent as SNI planning document
   - Divided rainwater and waste drainage

   b) social aspects
   - Society guidance in maintaining the drainage;
   - Cooperation improvement of government and personal in drainage management in Pekanbaru City;
   - Campaign and socialization of drainage management in media;
   - Society empowerment and participation in managing the drainage

   c) economic aspects
   - Policy and program synchronization of the capital government, local government and personal in managing the drainage;
   - Financial cooperation between government, personal and society.

   d) institutional aspects
   - Policy and program synchronization of the capital government, local government and personal in managing the drainage
   - Institution capacity improvement

4.2. Suggestion

Suggestions for the further research are:
- Drainage planning of environmental basis;
- Social approach in sustaining drainage management;
- Institutional model in drainage management;
- Review the policy in drainage management;
- Drainage model of environmental basis in individual scale;
- Drainage model of environmental basis in communal scale;
- The planning of residence, offices and the other public infrastructure absorption well;
- The Planning of Rainwater Container in residences, offices and the other public infrastructure;
- The planning of retention and detention around the area.

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