Study of flood discharge due to land use and population change of Way Pisang watershed

by Agustinus Purna Irawan

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Abstract. In some areas in Indonesia, especially those around rivers that develop into urban areas are always faced with the problem of flooding in each rainy season. Soil surface characteristics can affect surface runoff in some areas. In general, human activities will increase along with the rate of population growth which results in increased land conversion activities to meet the economic needs of an area. This study will examine the level of population growth around the Way Pisang watershed in South Lampung Regency in 2007 and 2019, which is expected to influence land use change as a result of activities to meet economic needs, which in turn will have an impact on changes in the drainage coefficient resulting in an increase flood discharge in the watershed. The results of this study can be concluded that from 2007 to 2019, population growth in the Way Pisang Watershed increased by an average of 9.62%. With population growth accompanied by changes in land use where forest area has decreased 81.39%, paddy fields 52.90% and shrubs 85.54%. While the area of settlements increased by 56.10% and dry agricultural land/gardens increased to 147.62%. This resulted in an increase in drainage coefficient of 102.18% which in turn resulted in an increase in flood discharge on average by 28.82%. Keywords: flooding, flow coefficient, population growth.

1. Introduction

In every region in Indonesia, especially those around rivers that develop into urban areas are always faced with the problem of flooding in each rainy season. The condition of land cover will affect the surface flow from rainfall that falls in a watershed in a certain time and eventually flows into the natural drainage channel / river. To be able to anticipate flood events, one of them needs to know the magnitude of drainage coefficient based on land use. The Way Pisang River hydrologically located in the Seputih-Sekampung River Region which is a national strategic River Region. While administratively crossing South Lampung Regency [1-5].

Every year in the rainy season at certain points the Way Pisang River experiences floods with low to moderate intensity and with varying inundation impacts at each flood location. To find out the amount of surface runoff in a watershed (DAS), it is necessary to observe and analyze activities on land use as land cover in a watershed [4], [6-10]]. Each type of land cover has a surface runoff coefficient value which states the estimated amount of rain that will flow on the surface of the land leading to a larger drainage channel. Land cover that has a high level of infiltration will help reduce the surface flow that occurs, and vice versa if the land cover has a low infiltration, then the surface flow that occurs will be even greater.

Flood events in the Way Pisang River Basin are floods that occur every year, on the other hand the growth rate of the population who live in the surrounding areas is increasingly dense, this

is evident from the increasing number of houses and buildings erected around the Way Pisang River.

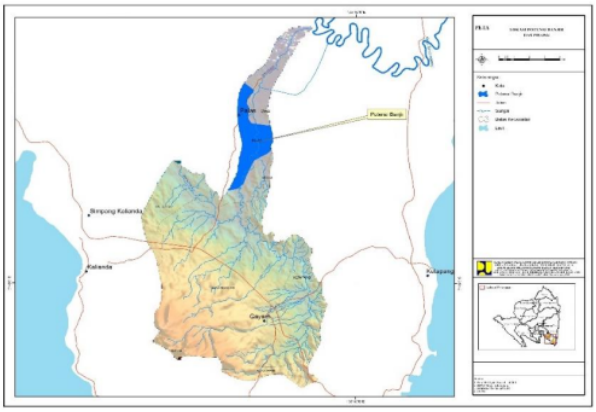

Figure 1. Location of Potential Floods in the Way Pisang Watershed

The objectives to be achieved in this study are knowing the growth rate of the population that affects changes in land use in the Way Pisang Watershed, knowing the changes in the value of the runoff coefficient in the Way Pisang watershed as a result of changes in land cover and knowing changes in flood discharge in the Way Pisang Watershed from 2007 to 2019 [11-14].

2. Method

In carrying out this research will be divided into several stages of activities as follows:

a. Analyzing the distribution of the locations of Rainfall Observation Posts around the Way Pisang Watershed;
b. Conduct an analysis of the Regional Maximum Rain (Rainfall Area) on the Way Pisang Watershed using the Polygon Thiesen method;
c. Calculate the flood discharge of the Way Pisang Watershed design;
d. Compile research conclusions on changes in design flood discharge from 2007 to 2019 as a result of changes in land use caused by population growth that is expanding its activities with land conversion activities in the Way Pisang River Basin [11-12].

3. Result and Discussion

a. Long of Way Pisang River
   Based on the results of data collection on the measurement of the Way Pisang River it is known that the Way Pisang River Length is 27.32 km.

b. Area of Way Pisang Watershed
   Based on the results of data collection and measurements on the Way Pisang watershed map has an area of 155.34 km^2.

c. Land Use of Way Pisang Watershed
   Based on the map of the Way Pisang watershed in 2007 and 2019, the following types of land use can be identified:

Table 1. Way Pisang Watershed Land Use in 2007

No	Land Use	Area (km^2)	%
1	Forest	74.03	47.66
2	Residential	3.44	2.21
3	Rice fields	19.85	12.78
4	Dry land agriculture /gardens	50.8	32.70
5	Thicket	7.22	4.65
	Total	**155.34**	**100**

Table 2. Way Pisang Watershed Land Use in 2019

No	Land Use	Area (km^2)	%
1	Forest	13.78	8.87
2	Residential	5.37	3.46
3	Rice fields	9.35	6.02
4	Dry land agriculture / gardens	125.79	80.98
5	Thicket	1.04	0.67
	Total	**155.34**	**100**

d. Population in Way Pisang Watershed

Based on data obtained from the Central Statistics Agency (BPS) in South Lampung Regency, it can be seen data on population in the Way Pisang Watershed as follows:

Table 3. Way Pisang Watershed Population in 2007

No	sub-district	Area (km^2)	Area in Watershed (km^2)	Population
1	Bakauheni	57.13	7.20	806
2	Kalianda	226.06	10.37	5321
3	Ketapang	180.93	4.02	1178
4	Palas	173.56	34.92	12243
5	Penengahan	97.59	97.59	25450
6	Sragi	93.44	1.24	262
	Total	**155.34**		**45260**

Table 4. Way Pisang Watershed Population in 2019

No	sub-district	Area (km^2)	Area in Watershed (km^2)	Population
1	Bakauheni	57.13	7.20	1133
2	Kalianda	226.06	10.37	6346
3	Ketapang	180.93	4.02	1385
4	Palas	173.56	34.92	13814
5	Penengahan	97.59	97.59	26648
6	Sragi	93.44	1.24	289
	Total	**155.34**		**49615**

e. Rainfall Observation Post around the Way Pisang Watershed

Based on the results of data collection and analysis there are 4 (four) Rainfall Observation Posts around the Way Pisang Watershed as can be seen in Table 5 below.

Table 5. Rainfall Observation Post around the Way Pisang Watershed

No	Name of Post	LS	BT	Data Availability
1	PH030 - Klaten	5°44'4.5562"	105°41'33.0431"	2008 - 2019
2	PH 031 - Purwodadi	5°40'58.700"	105°40'28.4000"	2008 - 2019
3	R 021 - Pasuruhan	5°44'42.500"	105°40'35.3000"	2008 - 2019
4	R 233 - Palas	5°36'4.1000"	105°41'44.8000"	2008 - 2019

f. Distribution of Rain Observation Posts in the Way Pisang Watershed

Based on the results of GIS analysis data, it can be seen the distribution of Rainfall Observation Post locations in the Way Pisang Watershed as can be seen in Figure 2.

g. Extent of Effect of Rain Observation Post on Way Pisang Watershed

Based on the results of GIS analysis data collection, the area of influence of each Rainfall Observation Post in the Way Pisang Watershed is as follows:

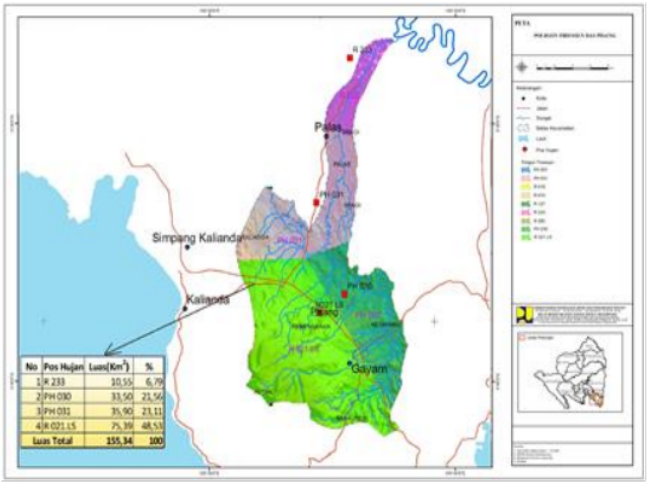

Figure 2. Map of the Distribution of Rain Posts in the Way Pisang Watershed

Table 6. Extent of Effect of Rain Observation Post on Way Pisang Watershed

No	Name of Post	Area (km^2)	% Area
1	PH030 - Klaten	33.5	21.566
2	PH 031 - Purwodadi	35.9	23.111
3	R 021 - Pasuruhan	75.39	48.532
4	R 233 - Palas	10.55	6.792
	Total	**155.34**	**100**

h. **Way Pisang Surface runoff coefficient**

Based on the type of land cover in Way Pisang River Basin, it can be seen that the drainage coefficient values in the Way Pisang River Basin are as follows:

Table 7. Runoff Coefficient of Way Pisang Watershed in 2007

No	Land Use	Area (km^2)	%	C	L.C
1	Forest	74.03	47.66	0.02	1.48
2	Residential	3.44	2.21	0.6	2.06
3	Rice fields	19.85	12.78	0.15	2.98
4	Dry land agriculture / gardens	50.8	32.70	0.4	20.32
5	Thicket	7.22	4.65	0.07	0.505
	Total	**155.34**	**100**		**27.35**
	C Average				**0.18**

Table 8. Average Flow Coefficient Based on the Way Pisang Land Use Land Use in 2007

Period	Runoff coefficient (C)							
	2	5	10	20	25	50	100	Average
Rain	0.83	0.66	0.58	0.52	0.51	0.47	0.43	
TGL	0.18	0.18	0.18	0.18	0.18	0.18	0.18	
Average	0.50	0.42	0.38	0.35	0.34	0.32	0.30	0.37

Table 9. Runoff Coefficient of Way Pisang Watershed in 2019

No	Land Use	Area (km^2)	%	C	L.C
1	Forest	13.78	8.87	0.02	0.28
2	Residential	5.37	3.46	0.6	3.22
3	Rice fields	9.35	602	0.15	1.40
4	Dry land agriculture / gardens	125.79	80.98	0.4	50.32
5	Thicket	1.04	0.67	0.07	0.073
	Total	**155.34**	**100**		**55.29**
	C rata-rata				**0.36**

Table 10. Average Flow Coefficient Based on the Way Pisang Land Use Land Use in 2019

Period	Runoff coefficient (C)							
	2	5	10	20	25	50	100	Average
Rain	0.74	0.62	0.56	0.51	0.5	0.47	0.44	
TGL	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
Average	0.55	0.49	0.46	0.43	0.43	0.41	0.40	0.45

i. **Design Flood of the Way Pisang Watershed**

By using the Nakayasu unit hydrograph, it can be seen that the Way Pisang River Design Flood according to the time of return is as follows:

Table 11. Way Pisang Watershed Design Flood in 2007

Period	Design Flood in 2007 (m^3/s)
KU – 2 year	123.65
KU – 5 year	193.58
KU – 10 year	245.48
KU – 20 year	303.72
KU – 25 year	316.93
KU – 50 year	374.22
KU – 100 year	434.98

Table 12. Way Pisang Watershed Design Flood in 2019

Period	Design Flood in 2019 (m^3/s)
KU – 2 year	185.34
KU – 5 year	264.35
KU – 10 year	319.61
KU – 20 year	379.22
KU – 25 year	392.41
KU – 50 year	448.70
KU – 100 year	506.91

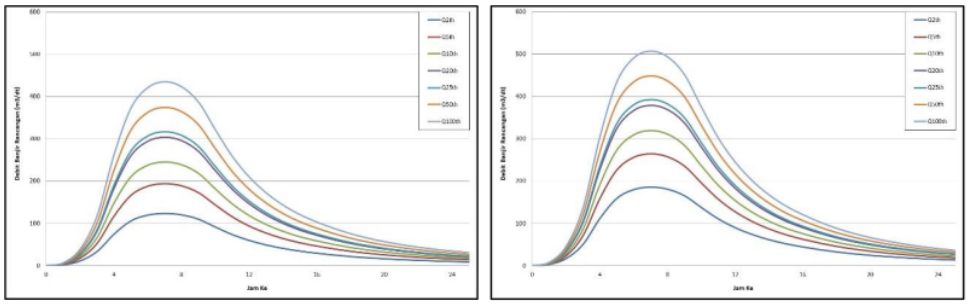

Figure 3. Way Pisang Watershed Design Flood in 2007 and 2019

4. Conclusion

Based on the results of the analysis and calculations that have been carried out in this study, the following conclusions can be obtained: The population in the Way Pisang Watershed from 2007 to 2019 increased by 4,355 inhabitants (9.62%), while the type of land cover experienced a significant change where forest area decreased 81.39%, settlement area increased 56.10%, paddy area experienced 52.90% decrease, dry land/garden area increased 147.62% and shrub land decreased by 85.54%, with the land cover condition causing drainage coefficient to increase by 102.18% so that it affected the amount of design flood discharge which experienced an average increase of 28.82 %.

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