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The Effect of Land use Changes on Runoff Discharge in Ampenan and Sekarbela District, Mataram City

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ABSTRACT: Changes in land use in Ampenan and Sekarbela Districts in the Mataram city area have occurred on a massive scale. The high level of infrastructure development and increasing population density has caused the area of green land to decrease and the built-up area to increase. This change in land function affects the land's ability to absorb rainwater that falls in an area. This research was conducted to determine the runoff discharge that occurred due to changes in land use in 2013, 2018 and 2023, and to compare the runoff discharge in 2023 with the runoff discharge based spatial plans on the 2011-2031. The analysis stage begins with water catchment area delineation and land use analysis with the help of ArcMap and Google Earth software. Then proceed with the calculation of runoff coefficient values, analysis of regional rainfall, analysis of rainfall plans, calculation of rain intensity, calculation of runoff discharge using rational methods and comparing runoff discharge that occurs in 2023 with runoff discharge based spatial plans on the 2011-2031. The research results show that there is a decrease in the area of green land and an increase in the area of built-up land which causes the runoff coefficient and runoff discharge values to increase. The increase in runoff discharge in Sekarbela District in 2013-2018 was 6.52%, in 2018-2023 was 2.81%, and in 2013-2023 was 9.52%. Meanwhile, the increase in runoff discharge in Ampenan District in 2013-2018 was 3.02%, in 2018-2023 was 2.10%, and in 2013-2023 was 5.18%.

KEYWORD : Delineation, Rain Plan, Runoff Discharge

INTRODUCTION

In the implementation of development, changes in land use and land function are inevitable (Lisdiyono, 2004). Based on population data from the Central Statistics Agency (BPS), the population of Mataram City in 2023 was recorded at 441,147 people with a population growth rate of 1.34%. Currently, the population density of Mataram City has reached 7,197 people/km2, an increase of 188 people/km2 from 2020 with a percentage increase of 2.68% (BPS, 2024). The increase in population density causes changes in the function of green land to built-up land which results in a reduction in open land for air absorption, so that air runoff in urban areas increases (Wardhani, 2022). One of the factors that influences the amount of runoff is changes in land use (Suripin, 2004).

Ampenan District and Sekarbela District are districts located in the downstream area so that this area is often affected by the high discharge of river water from upstream. The problem of flood accumulation in 2018 at many points spread across all districts of Mataram City was caused by rain that lasted quite a long time and was exacerbated by the high discharge of river water from upstream. In this condition, air catchment areas play an important role in controlling floods and surface flow (Fathan, 2021). Several previous studies on the analysis of land use changes in a River Basin Area (DAS) or area on the magnitude of flood discharge and runoff have been conducted by Budianto et al. (2022) in the Mandalika Special Economic Zone (KEK) with the results estimated that flood discharge will increase by 0,17% to 4,00% in 2030 and increase by 0,79% to 8,67% in 2045, Agustina's research (2023) in the Babak DAS was shown in a period of 7 years that the runoff discharge increased by 6,93%.

The purpose of this study was to determine changes in land use and runoff discharge in Ampenan and Sekarbela Districts in 2013, 2018, and 2023, as well as to determine the comparison of runoff discharge in Ampenan and Sekarbela Districts in 2023 with runoff discharge based on Regional Spatial Plan) RSP map of Mataram City for 2011-2031.

This research can be used as input and consideration for related stakeholders that in developing an area, it needs to be planned well so as not to cause environmental problems in this case flooding.

RESEARCH METHOD

Delineation of catchment area boundaries carried out with the help of ArcMap software with reference to topographic maps and Google Earth. Catchment area delineation is the process of determining an area that contributes to flowing rainfall into surface flow at an outlet point (Purwono et al., 2018). While the catchment area is an area or rain catchment area where the boundaries of the catchment area are determined from the highest to the lowest elevation points. Determination of the area of the rain catchment area is carried out by analyzing topographic maps with software (Manibuy & Perangin-Angin, 2022).

Land use analysis using Google Earth utilizes the historical features of world images from several years ago to then be analyzed with the help of ArcMap software. (Apriyanto et al., 2023).

Analysis of the determination of regional rainfall data using the Thiessen polygon method calculation. is carried out by calculating the area of influence of each station (Triatmodjo, 2008). The equation used is as follows:

$$\bar{p} = \frac{A_1 p_1 + A_2 p_2 + \dots + A_n p_n}{A_1 + A_2 + \dots + A_n}$$

with:

$\bar{p}$ = average rainfall of the region

$p_1, p_2, \dots, p_n$ = rainfall at stations 1, 2, 3,…, n

$A_1, A_2, \dots, A_n$= area representing stations 1, 2,…, n

Frequency analysis of rainfall to estimate the distribution of rainfall with a certain return period. According to (Soewarno, 1995), the methods that can be used in calculating design rainfall are the Normal Method, Log Normal Method, Gumbel Method and Log Pearson Type III Method.

Analysis of rain intensity using the Mononobe method. The general nature of rain is that the shorter the rain lasts, the higher the intensity tends to be and the greater the recurrence period and intensity (Suripin, 2004).

The design rainfall intensity can be determined using the Mononobe formula below because the duration of rainfall available from the automatic rain recording station is relatively short (Suripin, 2004).

$$I = \frac{R_{24}}{24}\left(\frac{24}{T}\right)^{2/3}$$

with:

I = rainfall intensity (mm/hour)

T = duration of rainfall (hours)

R_{24} = maximum rainfall in 24 hours (mm).

Analysis of planned runoff discharge using rational method. Planned discharge is the maximum discharge of a river with a certain recurrence period (Suripin, 2004). In this analysis, rational method is used to analyze planned flood discharge with the following formulation:

$$Q = 0{,}00278\ C.\ I.\ A$$

with:

Q = peak discharge caused by rain with a certain intensity, duration and frequency (m^3/second)

I = rain intensity (mm/hour)

A = catchment area (ha)

C = runoff coefficient that depends on the type of land surface.

Percentage analysis of the influence of land use changes on runoff discharge in the Ampenan and Sekarbela Districts.

Comparing the flood discharge obtained in 2023 with the Regional Spatial Plan (RSP) of Ampenan and Sekarbela Districts in 2011-2031.

RESULT AND DISCUSSION

Catchment Area Delineation

Catchment areas are created using ArcMap software by considering contours and viewing rivers, flow directions, and main roads on Google Earth. The results of the catchment area delineation are presented in Figure 1. Based on the delineation results, the number of catchment areas for Sekarbela District is 13 catchment areas and for Ampenan District is 12 catchment areas.

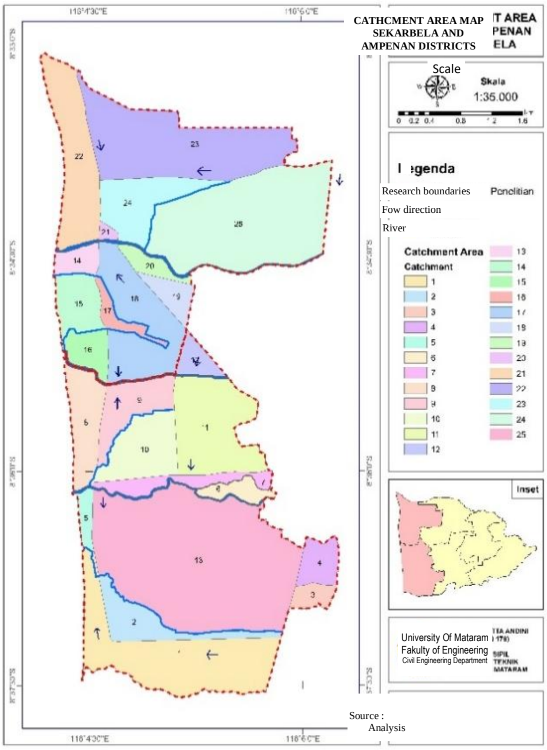


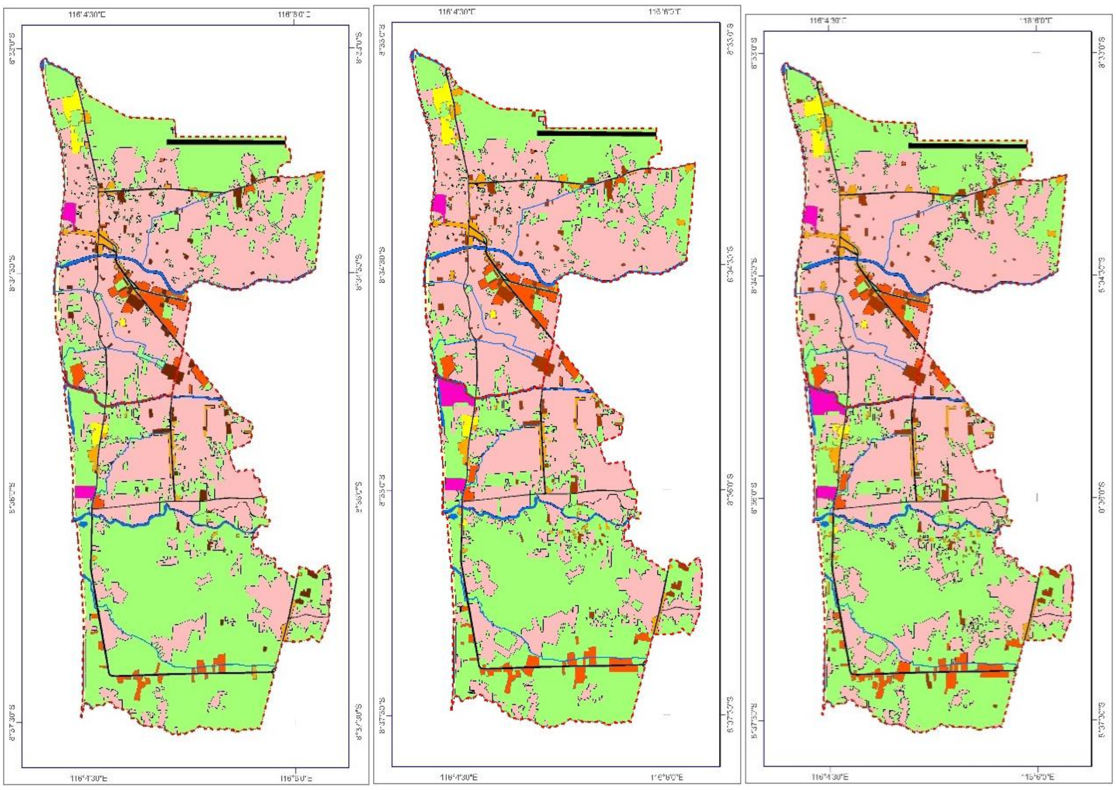
Figure 1. Catchment area

Land Use Analysis

Land use in 2013, 2018, and 2023

The land use classification is divided into 8, namely settlements, green open space (GOS), other buildings (education, health, military, and places of worship), industry, offices, pavement (roads), public cemeteries, trade and services. The results of the land use analysis based on calcification in 2013, 2018 and 2023 are presented in Figure 2.

Based on Figure 2 and Table 1, it can be seen that the total area of built-up land, which includes settlements, other buildings, industries, offices, trade and services, has increased. In Sekarbela District, the area of built-up land increased by 14,56% from 2013 to 2018, 7,13% from 2018 to 2023, and 22,73% from 2013 to 2023. Whereas in Ampenan District the percentage increase in 2013-2018 was 5,24%, in 2018-2023 it was 4,42% and in 2013-2023 it was 9,90%.



Year 2013 Year 2018 Year 2023

Figure 2: Land use map for 2013, 2018 and 2023

Table 1: Percentage of built-up land use and green land use in Sekarbela and Ampenan Districts

SEKARBELA DISTRICT							
Land use	Area (Ha)			% Land use			Description
	2013	2018	2023	2013-2018	2018-2023	2013-2023	
Built-up land	394,25	451,64	483,85	14,56	7,13	22,73	% increase
Green land	621,35	563,95	531,75	9,24	5,71	14,42	% decrease
AMPENAN DISTRICT							
Land use	Area (Ha)			% Land use			Description
	2013	2018	2023	2013-2018	2018-2023	2013-2023	
Built-up land	562,94	592,47	618,65	5,24	4,42	9,90	% increase
Green land	289,58	260,05	233,88	10,20	10,07	19,24	% decrease

Land Use based on RSP

The land use analysis of the RSP for Sekarbela and Ampenan Districts was based on the RSP map of Mataram City for 2011-2031. The results of the analysis of the RSP land use map for Sekarbela and Ampenan districts can be seen in Figure 3.

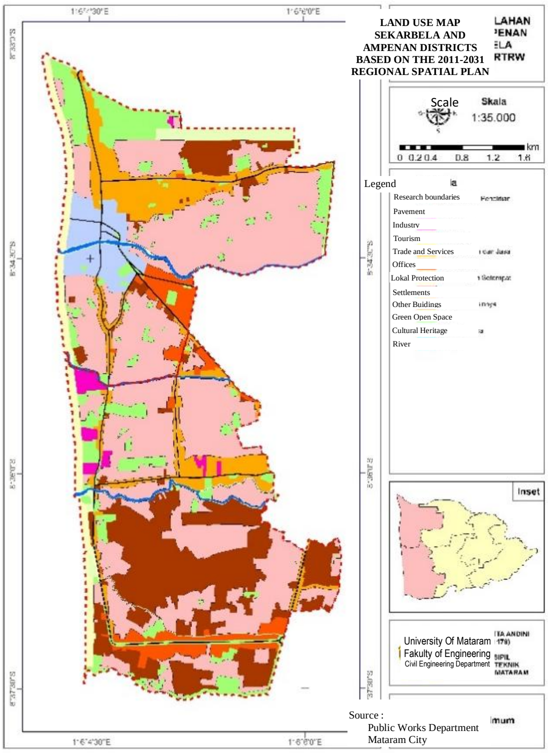


Figure 3: Land Use Map Based on RSP.

3.3. Runoff Coefficient

Runoff coefficient analysis for each cathment area based on the runoff coefficient value table Suripin, 2004 can be seen in table 2.

Table 2:Composite runoff coefficient in each Catchment Area Sekarbela District

Catchment Area	C_{2013}	C_{2018}	C_{2023}	C_{RSP}
1	0,27	0,29	0,30	0,55
2	0,34	0,45	0,47	0,58
3	0,39	0,39	0,39	0,63
4	0,40	0,40	0,40	0,67
5	0,25	0,28	0,31	0,34
6	0,43	0,46	0,46	0,52
7	0,55	0,55	0,55	0,57
8	0,33	0,41	0,43	0,40
9	0,44	0,45	0,46	0,54
10	0,54	0,54	0,54	0,55
11	0,55	0,55	0,56	0,59
12	0,61	0,61	0,61	0,62
13	0,29	0,31	0,33	0,64

Ampenan District

Catchment Area	C_{2013}	C_{2018}	C_{2023}	C_{RSP}
14	0,59	0,61	0,61	0,60
15	0,48	0,53	0,53	0,49
16	0,47	0,51	0,51	0,53
17	0,54	0,59	0,59	0,56
18	0,57	0,59	0,59	0,61
19	0,61	0,61	0,61	0,65
20	0,62	0,62	0,62	0,64
21	0,63	0,63	0,63	0,68
22	0,47	0,48	0,48	0,44
23	0,34	0,36	0,37	0,46
24	0,58	0,58	0,60	0,61
25	0,49	0,50	0,52	0,57

3.4. Rainfall Analysis Area

The rainfall of the area was calculated based on the Thiessen polygon method using ArcMap software. The total area of the analysed catchment area is 19,68 km^2 . From the analysis, there are only two influential stations, namely Gunung Sari Rain Station with an influence area of 18,79 km^2 or 95,49% and Bertais station with an influence area of 0,89 km^2 or 4,51%.

3.5. Frequency Analysis

Based on the value of statistical parameters, the selected rain data distribution is Log Normal. By using a 10-year return period, the design rainfall value is 133,10 mm. Furthermore, the design rain value is used to calculate the rain intensity value.

3.6. Runoff Discharge

The planned runoff discharge is calculated using the rational equation for each catchment area for the years 2013, 2018, 2023, and based on the RSP map. A recapitulation of the runoff discharge calculation results can be seen in Table 3.

Table 3: 10-year return period runoff discharge (Q10) at each cathment area

Catchment Area	2013 (m3/second)	2018 (m3/second)	2023 (m3/second)	RSP (m3/second)	%
SEKARBELA DISTRICT					
1	6,23	6,84	7,10	12,79	44%
2	3,35	4,39	4,56	5,62	19%
3	1,52	1,52	1,52	2,41	37%
4	2,38	2,38	2,38	3,96	40%
5	0,87	0,97	1,07	1,16	7%

Catchment Area	2013 (m3/second)	2018 (m3/second)	2023 (m3/second)	RSP (m3/second)	%
6	1,98	2,13	2,13	2,42	12%
7	3,98	3,98	3,98	4,15	4%
8	3,46	4,26	4,41	4,18	**-6%**
9	4,28	4,40	4,48	5,30	15%
10	6,32	6,36	6,37	6,45	1%
11	9,68	9,81	9,89	10,36	5%
12	2,82	2,82	2,82	2,90	3%
13	12,56	13,41	14,32	27,80	48%
TOTAL	59,40	63,28	65,06	89,50	
AMPENAN DISTRICT					
14	2,78	2,85	2,87	2,82	**-2%**
15	3,88	4,25	4,31	3,98	**-8%**
16	2,86	3,10	3,10	3,20	3%
17	2,27	2,49	2,49	2,34	**-7%**
18	9,84	10,06	10,10	10,44	3%
19	3,12	3,12	3,12	3,30	6%
20	2,79	2,80	2,80	2,88	3%
21	0,98	0,98	0,98	1,06	7%
22	7,61	7,79	7,89	7,19	**-10%**
23	8,67	9,25	9,45	11,97	21%
24	6,84	6,86	7,16	7,26	1%
25	15,30	15,41	16,14	17,64	8%
TOTAL	66,93	68,95	70,40	72,90	

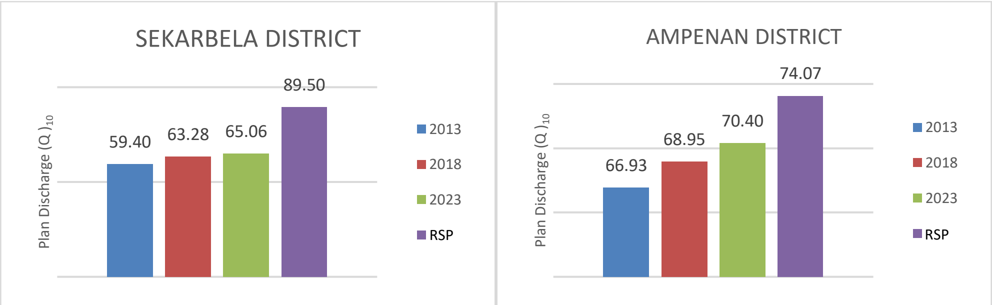


Figure 4:Comparison Q_{10} Sekarbela and Ampenan Districts

The figure 4 shows an increase in planned runoff discharge in Sekarbela and Ampenan Districts in 2013, 2018, 2023 with a percentage increase in runoff discharge in Sekarbela District in 2013-2018 of 6,52%, in 2018-2023 of 2,81%, and in 2013-2023 of 9,52%. While the percentage increase in runoff discharge in Ampenan District in 2013-2018 was 3,02%, in 2018-2023 was 2,10%, and in 2013-2023 was 5,18%. Similarly, in the 2011-2031 RSP, it is estimated that there will be an increase in runoff discharge from 2023 until the runoff discharge based on the RSP in the next few years will increase very significantly in Sekarbela District with a percentage increase of 37,58% and in Ampenan District by 5,21%.

Comparison of Runoff Discharge Year 2023 with RSP

A comparison between the 2023 runoff discharge and RSP of the 2011-2031 for Sekarbela and Ampenan Districts with a 10-year return period can be seen in Table 4 below:

Table 4. Comparison of Runoff Discharge Based on Land Use in 2023 with the RSP

Catchment Area	Q_{10} (m^3 /second)		%
	2023	RSP	
SEKARBELA DISTRICT			
1	7,10	12,79	44%
2	4,56	5,62	19%
3	1,52	2,41	37%
4	2,38	3,96	40%
5	1,07	1,16	7%
6	2,13	2,42	12%
7	3,98	4,15	4%
8	4,41	4,18	**-6%**
9	4,48	5,30	15%
10	6,37	6,45	1%
11	9,89	10,36	5%

12	2,82	2,90	3%
13	14,32	27,80	48%
AMPENAN DISTRICT			
14	2,87	2,82	**-2%**
15	4,31	3,98	**-8%**
16	3,10	3,20	3%
17	2,49	2,34	**-7%**
18	10,10	10,44	3%
19	3,12	3,30	6%
20	2,80	2,88	3%
21	0,98	1,06	7%
22	7,89	7,19	**-10%**
23	9,45	11,97	21%
24	7,16	7,26	1%
25	16,14	17,64	8%

Table 5 shows that the comparison of runoff discharge (Q10) in 2023 in Sekarbela and Ampenan Districts as a whole has not reached the runoff discharge (Q10) based on the 2011-2031 RSP. However, in some cathment areas the 2023 runoff discharge exceeds the RSP runoff discharge as indicated by the negative sign in the table above. This condition makes it possible that other cathment areas will also experience the same thing if no control of built-up land is carried out. Negative impacts on the environment can cause inundation and flooding.

CONCLUSIONS

Based on the results of the analysis and discussion that has been carried out, the following conclusions can be drawn:

1. Land use analysis in Ampenan and Sekarbela Districts showed land use change between 2013 and 2023 with decreasing green areas and increasing built-up areas with a percentage increase in built-up areas in Sekarbela District in 2013-2018 of 14,56%, in 2018-2023 of 7,13%, and in 2013-2023 of 22,73%. Whereas in Ampenan District, the percentage increase in built-up area in 2013-2018 was 5,24%, in 2018-2023 was 4,42%, and in 2013-2023 was 9,90%.
2. There was an increase in the value of the runoff coefficient in Ampenan and Sekarbela Districts due to land use change from 2013 to 2023 which affected the amount of runoff discharge that occurred in 2013, 2018, and 2023 with a percentage increase in runoff discharge in 2013-2018 of 6,52%, in 2018-2023 of 2,81%, and in 2013-2023 of 9,52%. Meanwhile, the percentage increase in runoff discharge in Ampenan District in 2013-2018 was 3,02%, in 2018-2023 was 2,10%, and in 2013-2023 was 5,18%.
3. The comparison of runoff discharge (Q_{10}) in 2023 in Sekarbela and Ampenan District as a whole has not yet reached the runoff discharge (Q10) based on the 2011-2031 RSP. The increase in runoff discharge that occurs from 2023 to the next few years based on the RSP is expected to experience a very significant increase in Sekarbela District with an estimated percentage increase of 37,58% and in Ampenan District of 5,21%.

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