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Analysis of the Effects of Land-Use Changes on Increased Flood Discharge in the Hetuma River Using a Hydrological Approach

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Keyword:
land use change; flood discharge; hydrology; Nakayasu Synthetic Unit Hydrograph; rational method.

ABSTRACT

Changes in land use due to residential expansion and infrastructure development have increased surface runoff, contributing to higher flood discharge in the Hetuma River, Jayawijaya Regency. This study aimed to analyze the impact of land-use changes on increased flood discharge and develop an optimization model for drainage systems to reduce inundation in Wamena City. The research employed a hydrological approach using the Nakayasu Synthetic Unit Hydrograph (Hidrograf Satuan Sintetis or HSS) method and the Rational Method. The data used included BMKG rainfall records from 2013–2024, topographic data, watershed maps, and land-cover maps from 2015 and 2025. The results showed that forest areas decreased from 217.70 ha to 139.39 ha, while residential areas increased from 177.67 ha to 183.17 ha. These land-use changes increased the runoff coefficient, which subsequently contributed to higher flood discharge. Based on the Nakayasu Synthetic Unit Hydrograph method, the design flood discharge of the Hetuma River reached 20.712 m³/s for the 2-year return period and 26.474 m³/s for the 100-year return period. Meanwhile, the Rational Method results indicated that flood discharge increased from 281.970 m³/s for the 2-year return period to 504.967 m³/s for the 100-year return period. Drainage analysis revealed that several channels in the Hom-Hom area were unable to accommodate runoff discharge due to sediment accumulation and limited channel capacity, requiring channel normalization and dimension improvements. Therefore, land-use changes were proven to contribute to increased flood discharge in the Hetuma River, highlighting the need for land-use management and drainage system optimization to reduce flood risks in Wamena City.

INTRODUCTION

The growth of urban areas and the expansion of development activities have significantly influenced changes in drainage systems (Bibi et al., 2023; Das et al., 2024; Francisco et al., 2022; Hassan et al., 2022; Khan et al., 2024; Le et al., 2024; Liu et al., 2022). The increase in built-up areas directly contributes to higher runoff coefficients and greater surface runoff discharge from rainfall events, particularly with increasing rainfall intensity and drainage limitations (Djamaluddin et al., 2025; Nilap et al., 2025; Odiji et al., 2026; Pochodyła-Ducka et al., 2023; Yadav & Dey, 2025). These conditions may lead to flooding and inundation due to reduced water infiltration areas and inadequate drainage systems. Therefore, improvements in drainage infrastructure are required to mitigate these risks (D'Ambrosio & Longobardi, 2023; Esraz-Ul-Zannat et al., 2024; Osheen et al., 2024; Wang et al., 2024; Ye et al., 2025). Urban drainage refers to a water management system designed to collect, convey, and control stormwater runoff in urban areas, including residential areas, industrial zones, commercial areas, educational facilities, public and social facilities, green open spaces, military areas, and electricity and telecommunication infrastructure.

Wamena City, as one of the developing urban centers and the capital of Mountainous Papua Province, has experienced significant expansion of built-up areas, including residential settlements and supporting infrastructure. The drainage sector has become one of the city's development priorities, considering that the existing drainage conditions in Wamena City do not fully meet technical requirements (Riswanto et al., 2023; Widya et al., 2023; Wulandari et al., 2025). Several issues include ineffective inlets for collecting surface runoff, drainage channel inlets positioned higher than the road surface elevation, insufficient channel capacity to accommodate runoff discharge, and incomplete drainage network connectivity, where some channels do not discharge properly into the main drainage system. In addition, many drainage networks use closed systems with limited maintenance facilities, such as insufficient manhole access, and routine maintenance activities are rarely conducted, particularly before the rainy season or at least once annually after the dry season.

Jayawijaya Regency generally has a hilly and mountainous topography, forming part of the Jayawijaya Mountain range. However, relatively extensive lowland areas are found in the Baliem Valley, which is a mountainous plain where Wamena City is located. The topographical conditions of Jayawijaya Regency vary from flat, gently sloping, undulating, to mountainous areas, with land slopes ranging from 0% to 45%.

Figure 1. Wamena City Drainage Situation (Hetuma River and Helomema River) (Source: Documentation, 2026)

This condition has the potential to cause inundation because Wamena City, which has a basin-like topography, may become vulnerable to flooding if the drainage system is not properly managed. Effective water flow management toward lower areas and increasing infiltration capacity are necessary to reduce surface runoff. Therefore, the provision and optimization of drainage infrastructure are required to minimize the risk of inundation and ensure that the drainage system functions effectively.

Based on the background described above, this study aimed to investigate the Analysis of the Effects of Land-Use Changes on Increased Flood Discharge in the Hetuma River Using a Hydrological Approach.

Based on the identified problems, the research questions were formulated as follows: (1) How do land-use changes affect flood discharge in the Hetuma River? (2) What optimization model can be applied to drainage channels to mitigate inundation in Wamena City?

Based on these research questions, the objectives of this study were: (1) to determine the effect of land-use changes on flood discharge in the Hetuma River; and (2) to develop an optimization model for drainage channel utilization in reducing inundation in Wamena City.

To maintain focus and ensure alignment with the research objectives, the scope of this study was limited to the following aspects: the research area was restricted to the Hetuma River located in Wamena District; the hydrological analysis employed the Nakayasu Synthetic Unit Hydrograph (Hidrograf Satuan Sintetis or HSS) method and the Rational Method; and the drainage systems analyzed were limited to channels within Wamena District that directly discharge into the Hetuma River.

The results of this study are expected to provide theoretical and practical contributions. The theoretical contributions include applying flood control theories to real-world cases, enriching the development of flood management concepts, and producing scientific insights related to flood problems and mitigation strategies. The practical contributions include providing recommendations and input for the Jayawijaya Regency Government in addressing flood control issues in Hubikia District and Wamena District, serving as a reference for relevant stakeholders in flood management efforts, and increasing public awareness regarding the importance of environmental management to reduce flood risks.

METHOD

Research Location

This research was conducted in Jayawijaya Regency, Mountainous Papua Province. Geographically, Jayawijaya Regency is located between 138°30′–139°40′ East Longitude and 3°45′–4°20′ South Latitude, with a total area of 13,925.31 km². Since 2011, the regency has been administratively divided into 40 districts. Jayawijaya Regency is the only regency in Mountainous Papua Province that does not have a coastal area. The administrative map of Jayawijaya Regency is presented below.

Figure 2. Map of Jayawijaya Regency Administration

This research focused on Wamena Kota District and Hubikia District, where the Heloima and Hetuma Rivers flow through these areas. The locations of the river points analyzed in this study are presented in the following map.

Figure 3. Map of the Location Point of the Heloima River and the Hetuma River

Data Collection Methods

The data sources in this study are divided into two, namely primary data and secondary data. Primary data is data obtained directly by researchers (first hand) through questionnaires, observations, panels, researcher interviews with sources, and testing or measurement. Meanwhile, secondary data is data obtained by researchers from existing sources (second hand), such as records or documents in companies or related agencies in the form of scientific publications, research reports, government reports, financial reports, data obtained from magazines, etc.

Primary data in the study is data obtained from the field with direct measurements, and observations in the field or at the research site. Secondary data in this study was obtained from agencies such as the Meteorology and Geophysics Agency, the Center for Geological Research and Development, the National Survey and Mapping Coordinating Board (Bakosurtanal), and other related agencies.

Data Analysis Methods

In this study, the researcher used several analysis methods, including:

1. Topographic Data Analysis

   To analyze topographic data from the Heloima River and the Hetumama River, the researcher will conduct a topographic survey of the Heloima River in Wamena City District and the Hetuma River in Hubikiak District.

2. Hydrological Analysis

   To calculate rainfall in the Heloima River and Hetuma River areas, researchers used rainfall frequency analysis using several probability distributions that are widely used in Hydrology.

3. Flood Discharge Analysis of the Heloima River and Hetuma River Plan

   The methods used in this analysis are the Nakayasu Synthetic Unit Hydrograph Method and the Rational Method.

Table 1. Infiltration Rate (cm/h) according to Soil group SCS

Soil Group	Description	Infiltration Rate
A	Deepsand, deeploess, aggregatedsilts	0.762–1.143
B	Shallow, loess, sandyloam	0.381–0.762

Soil Group	Description	Infiltration Rate
C	Clayloams, shallow, sandyloam, soil in organik content, and soils usually high in clay	0.127–0.381
D	Soils that's well significantly when wet, heavy plastic clays, and contain saline soils	0.000–0.127

Source: SCS, 1986; Skaggs and Khaleel, 1982

For the interpretation of land type maps, where there are various types of soil, for hydrological modeling it is divided into several groups, there are 4 groups A, B, C and D. The division of this group is made to obtain a *Curve Number* (CN) value, which in this case also takes into account the use of land from a watershed. From the type of land in the location of the work area, it can be estimated that it is included in the land group between A and B. The amount of CN for each land use is taken under moderate/fair conditions. The CN quantity for each Sub Watershed can be calculated by means of composite CN.

RESULTS AND DISCUSSION

Hydrological Analysis

In determining the drainage performance in the Hetuma, it is necessary to estimate the size of the flood discharge that may occur at the work site. Because the flood observation period at the work site is inadequate, the flood estimate is calculated based on rain data. The magnitude of flooding that occurs in an area is greatly influenced by the height and intensity of regional rainfall, watershed area, and land use.

The analysis of rain data is intended to prepare processed rain data for the purpose of further analysis. In this study, the analyses that require processed rain data are each designed rainfall analysis and planned flood discharge analysis.

Rain Data

Maximum daily rainfall from the rain stations at the study site, which is required for the preparation of a water use plan and a flood control plan. Average rainfall from several rain stations if present in all areas under review. This rainfall is called area rainfall expressed in mm. The average rainfall of this area is used to obtain rainfall that can represent an area under review.

In the implementation of this research work, rain analysis uses a rain station, namely the Jayawijaya Meteorological Station. The calculation of the annual maximum daily regional rainfall in this study uses data from 2013 to 2024 as seen in the following table.

Table 2. BMKG Maximum Rainfall Data Wamena Meteorological Station, Jayawijaya

NO	MONTHS	RAINFALL YEAR (mm)											
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1	January	36.8	23.2	26.7	40.3	23.9	57.8	93.2	30.6	23.3	28.8	19.9	10.1
2	February	54.4	12.6	19	28.1	24.5	54.1	40	21.2	48	82.4	23.8	20.5
3	March	27.7	25	20.2	31	22.5	28.6	60	35	34.7	34.4	25.9	34.9
4	April	33.6	20.4	25.8	32.4	16.7	41.7	35.2	42.5	33.1	19.6	30	23
5	May	28.4	15.9	42.2	17.2	16	65.3	23.4	13.3	32	66.5	27.3	31.2
6	June	27.9	24.3	21.9	13.5	14.7	18	18.8	24	61.5	29.4	22.5	32.5
7	July	46.8	15.2	4	25.3	27.1	38.5	20.5	21.9	13.2	22.8	39.7	28.6

NO	MONTHS	RAINFALL YEAR (mm)											
		2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
8	August	36.2	8.9	26.4	9.8	25.6	27.6	17	18.5	19.3	24.1	23.4	22.8
9	September	12.8	28	0	26	37	31.4	37	6	17.8	24.5	47	24.3
10	October	28.5	33.2	28.9	24.4	39	19.7	21.2	28.6	35.5	17.4	46.6	40.6
11	November	32.1	23	35.5	23.8	19.7	32.5	10.4	57.2	43.6	29	22.6	20.4
12	December	24	31.5	61.1	23.8	18.9	32.2	27.6	41	53.6	39.4	24.3	21.2
Maximum		**54.4**	**33.2**	**61.1**	**40.3**	**39.0**	**65.3**	**93.2**	**57.2**	**61.5**	**82.4**	**47.0**	**40.6**

Source: BMKG Data of Jayawijaya Meteorological Station (2026)

Before calculating rainfall, the plan must first determine the rainfall area that represents the work site and the average rainfall is the result of the sum of the rainfall at each station divided by the number of rain stations. From the results of the rainfall data consistency test that has been carried out, corrected rainfall data is obtained from each rain measurement station.

Data for Analysis

In the hydrological calculation carried out, data is needed, namely the map of the Hetuma River watershed to obtain the catchment area of the Hetuma river in Jayawijaya Regency which is needed in the design discharge analysis. The following is a map of the Hituma River watershed.

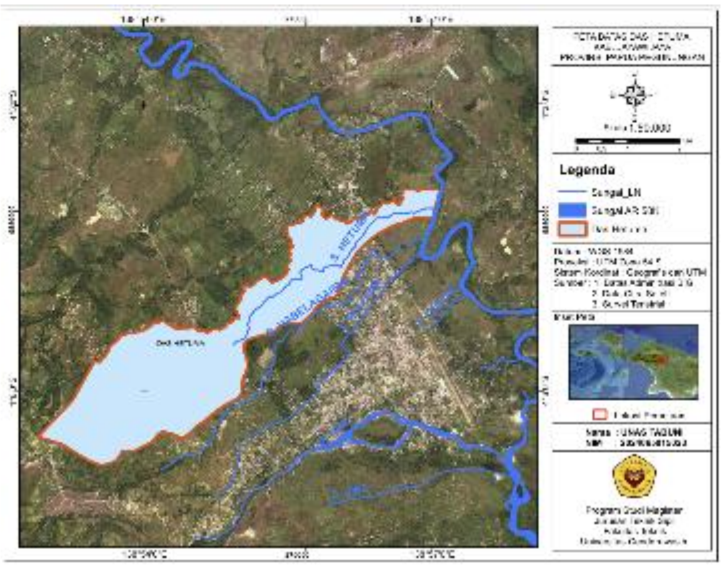

Figure 4. Hetuma River Watershed Map
(Source: Data Analytics, 2026)

In planning the planned discharge, a flow map on the Hetumas River is also needed, in order to know the direction of the final disposal on the Hetuma River, Jayawijaya Regency. So that if the flow is clogged or cannot flow to the area that should be a catchment or water disposal area, with this flow direction map, good water disposal can be determined so that flooding does not occur. The following is the land cover in 2015 and 2025 of the Hetuma.

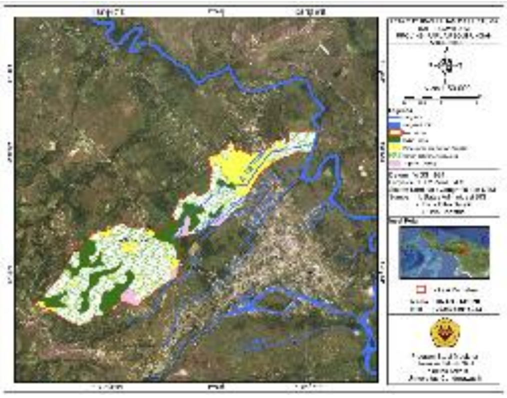

Figure 5. Hetuma River Land Cover Map in 2015
(Source: Data Analytics, 2026)

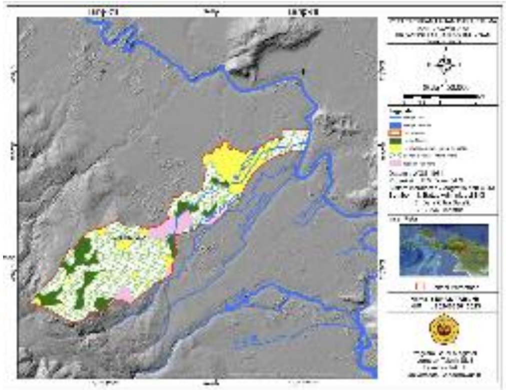

Figure 6. Hetuma River Land Cover Map in 2025
(Source: Data Analytics, 2026)

Table 3. Land Cover Change Area of the Hetuma River

Land Cover Change	2015 Expansion (Ha)	2015 Expansion (Ha)
Jungle Forest	217.70	139.39
Settlements and Places of Activity	177.67	183.17
The Bushes / For the Sake of It	616.38	649.25
Farm / Farm	39.45	79.39
Quantity	1051.20	1051.20

Source: Data Analytics (2026)

Discharge Analysis Procedure

The discharge analysis of the design is carried out by the following procedure:

1. Determination of *catchment area* boundaries and river data from topographic maps and land use maps.
2. Rainfall analysis was designed using *the Gumbel method, Pearson Log Type III,* and *Log Normal*.
3. Test the conformity of the distribution with *the Chi-Square* and *Smirnov-Kolmogorof methods*.
4. Discharge analysis of the design using the Rational method and Hydrograph of the Nakayasu Synthetic Unit.

Flood Discharge Analysis Plan

The design discharge is needed as a reference data for the analysis of the maximum water level on the Hetuma River, Jayawijaya Regency. The methods used to analyze the design discharge in this study are the Nakayasu Synthetic Unit Hydrograph Method and the Rational Method.

Table 4. Hetuma River Data

River Data				
Districts	**River Flow**	**Length (m)**	**Elv Hulu (m)**	**Elv Hilir (m)**
A	**B**	**C**	**D**	**E**
Jayawijaya	Hetuma	5596.62	1675	1635

Source: Data Analytics (2026)

1. Nakayasu Unit Hydrograph Method

The hydrographic ordinates of Nakayasu units are calculated as follows:

Ordered Hydrograph Points: $$q_p = \frac{C \cdot A \cdot R_0}{3{,}6\left(0{,}3T_p + T_{0{,}3}\right)}$$

With

A = catchment area

R0 = unit rainfall (= 1 mm)

Tp = time from the beginning of the rain to the peak discharge (*A Time of Lag*); hours.

T0.3 = time from the peak discharge to the discharge of 30 % (= 0.3) peak discharge

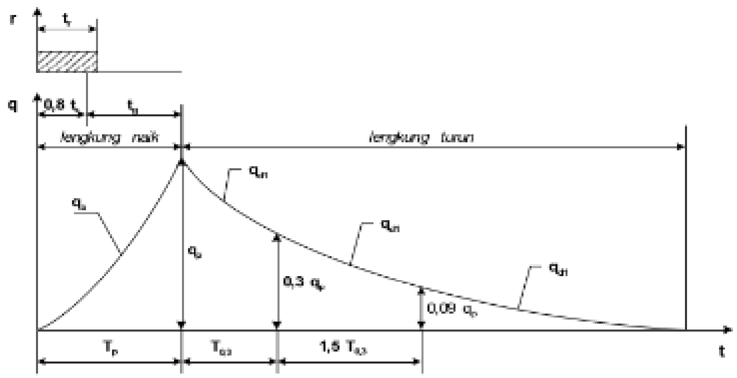

Figure 7. Synthetik Satuan Hydrographer Nakayasu

Tp lag time is calculated by the equation: $T_p = 0{,}8t_r + tg$

With tr = effective rainfall duration (taken 0.5 t_g to tg)

TG = concentration time, depending on the length of the main river; Calculated as follows:

If L ≤ 15 km, then $t_g = 0{,}21L^{0{,}7}$

If L > 15 km, then $t_g = 0{,}4 + 0{,}058L$; L in km and tg in hours.

T0,3 is calculated by the equation: $T_{0{,}3} = \alpha \cdot t_g$

with α = 2.0 for normal drainage areas,

α = 1.5 For drainage areas where the curve rises, the hydrograph rises more slowly and the curve descends faster.

α = 3.0 For drainage areas where the curve rises the hydograph is faster and the curve descends more slowly.

Ordinates on the ascending curve (t < Tp): $q_a = q_p \times \left(\frac{t}{T_p}\right)^{2{,}4}$

Ordinates on the descending curve (t > Tp):

- for Tp < t < T0,3 : $q_{d1} = q_p \times 0{,}3^{\left(t - T_p\right)/T_{0{,}3}}$
- for T0.3 < t < 2.5 T0.3 : $q_{d2} = q_p \times 0{,}3^{\left(t - T_p + 0{,}5T_{0{,}3}\right)/\left(1{,}5T_{0{,}3}\right)}$

- for t > 2.5 T0.3 : $q_{d3} = q_p \times 0{,}3^{(t-T_p+1{,}5T_{0,3})/(2T_{0,3})}$

The discharge of floods due to rain with an intensity of ***I*** mm/hour, is calculated by the equation: $Q(t,I) = q(t,1) \times I$

For rain with a duration of more than 1 hour, with the intensity of I1, I2, I3, . . ., In, respectively; The total discharge is calculated by the following superposition method: $Q(t) = q(t,1) \times I_1 + q(t-1,1) \times I_2 + q(t-2,1) \times I_3 + \cdots + q(t-(n-1),1) \times I_n$

To determine the intensity of rain per hour, the Mononobe formula is used as follows:

$$I = \left(\frac{R_{24}}{t}\right)\left(\frac{t}{T}\right)^{2/3} \qquad r_T = t \,.\, Rt - (t-1) \,.\, R_{(t-1)}$$

where :

r_T = Rainfall in hours to T (mm)

Rt = Average rainfall from start to hour to T (mm)

T = Time from rain to T (hour)

R24 = Effective rainfall in 24 hours (mm)

t = Rain concentration time (hours)

Using rainfall, the recapitulation of the calculation results is shown in Table 5 below

Table 5. Recapitulation of Flood Discharge Calculation with Nakayasu Method and Existing Flood Discharge

Rekapitulasi				
No	Districts	River Names		
			2 Years	5 Years
1	Jayawijaya	Hetuma	20.712	22.413

Source: Data Analytics (2026)

The following is a hydrographic graph of the river on the Hetuma River:

Table 6. Nakayasu Synthetic Unit Hydrograph Calculation Table on the Hetuma River

No	Re-Period	Method
	(Year)	HSS Nakayasu (m3/det)
1	2	20.712
2	5	22.413
3	10	23.506
4	25	24.769
5	50	25.641
6	100	26.474

Source: Data Analytics (2026)

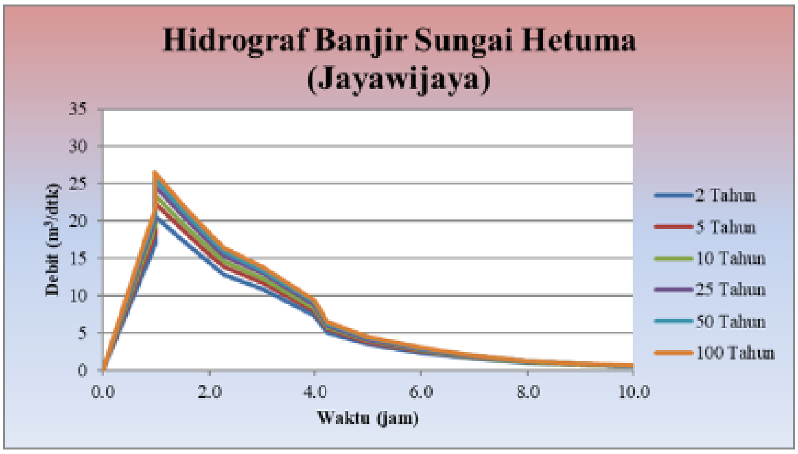

Figure 8. Flood Hydrograph for the Hetuma River

2. Flood Discharge Calculation Using a Rational Method

To estimate the magnitude of *peak runoff* (Qp) the rational method (*U.S. Soil Conversation Service*, 1973) is one of the considered good engineering methods. This method is one of the methods that is categorized as practical in estimating the magnitude of Qp to design buildings to prevent flooding, erosion and sedimentation. Analyze peak discharge using the equation:

Qp = 0,278 C . I . A

With:

Qp = peak flood discharge (m3/year)
C = flow coefficient
I = average rainfall intensity during concentration time (mm/h)
A = watershed area (km2)

The following are the results of the calculation of the planned flood discharge using a rational method:

Table 7. Flood Discharge Hetuma River Plan Rational Method

Period of project Ulang	IT	C	A	QT
2	120.610	0.80	10.512	281.970
5	147.746			345.411
10	165.044			385.850
25	186.031			434.917
50	201.160			470.287
100	215.995			504.967

Source: Data Analytics (2026)

Changes in land use have a significant influence on increasing flood discharge in a watershed. The conversion of vegetated land, such as forests, shrubs and natural open land into built-up areas, causes a drastic reduction in soil infiltration capacity. This decrease in the soil's ability to absorb water results in most of the rainfall turning into *surface runoff* that moves quickly towards drainage networks and rivers.

In addition, the increase in the area of watertight surfaces such as roads, dense settlements, and commercial buildings accelerates the flow concentration time, so that the peak of flood discharge occurs faster and with a larger volume. The loss of water-retaining vegetation also reduces the ability of catchment areas to hold and delay flows, so that the river's peak discharge increases significantly during high-intensity rains.

Overall, uncontrolled land-use changes lead to an increase in runoff coefficients, acceleration of surface flows, a decrease in natural holding capacity, and narrowing of channels, which cumulatively increase flood discharge and the frequency of flood events in the affected areas. The following is a map of land use changes in the Hetuma river in 2015 and in 2025.

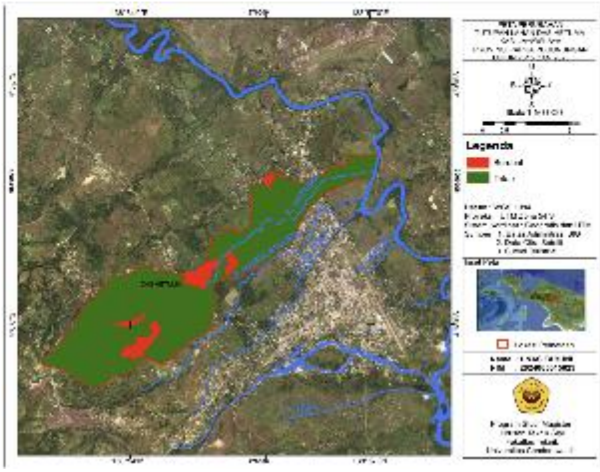

Figure 9. Land Use Change Areas on the Hetuma River

Based on the map above, there are areas on the Hetuma river that have experienced changes in land use, this change greatly affects the flood discharge that must be flowed into the Hetuma river. The following is a calculation of flood discharge with changes in land use in 2015 and 2025.

Table 8. Calculation of Planned Flood Discharge in the Hetuma River on Land Change

Year	Land Use Conditions	Grade C	Grade A	Q10 Years (m3/s)	Q10 Years (m3/s)	Q25 Year (m3/s)	Q25 Year (m3/s)
2015	Jungle Forest	0..3	2.177	29.965	185.669	33.776	210.563
	Settlements and Places of Activity	0.75	1.777	61.139		68.914	
	The Bushes / For the Sake of It	0.3	6.164	84.842		95.631	
	Farm / Farm	0.6	0.395	9.723		12.242	
2025	Jungle Forest	0.3	1.394	19.187	193.441	21.626	218.040

Year	Land Use Conditions	Grade C	Grade A	Q10 Years (m3/s)	Q10 Years (m3/s)	Q25 Year (m3/s)	Q25 Year (m3/s)
	Settlements and Places of Activity	0.75	1.832	63.031		71.047	
	The Bushes / For the Sake of It	0.3	6.492	89.367		100.731	
	Farm / Farm	0.6	0.794	21.857		24.636	

Source: Data Analytics (2026)

Based on the analysis of the data above, it can be seen that the effect of land use change is directly proportional to the amount of planned flood discharge on the Hetum river.Drainage Flood Discharge Analysis

In Jayawijaya Regency, especially Wamena City, there are locations that are often flooded by water in the area because there is no way for water to flow into the main river. High rainfall, accompanied by the topographic conditions of the valley surrounded by mountains, makes rainwater quickly accumulate in settlements. However, the absence of adequate drainage channels makes the water have no exit route, so that it overflows and inundates houses, roads, and public facilities.

The absence of drainage shows the weak spatial planning and urban infrastructure in Wamena City. The existing municipal drainage does not function optimally because it is not connected to sewers from residential areas. As a result, any heavy rain has the potential to become a disaster, causing economic losses, disrupting people's mobility, and increasing health risks. Flooding in Wamena is thus not only a natural phenomenon, but a consequence of the lack of an integrated urban drainage system. Without the construction of adequate sewers, Wamena will continue to face a flood cycle that is detrimental to the community.

There are 3 areas that are often flooded by floods in Wamena City, namely at the location of the Airport, Hom Hom, and in Wouma.

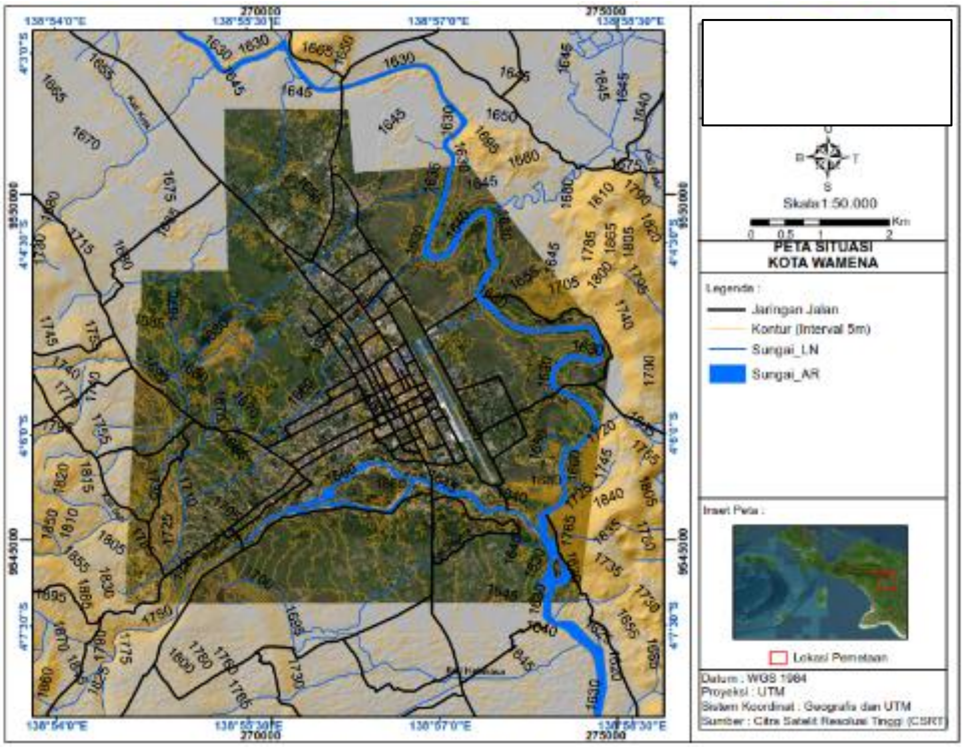

Figure 10. Map of the Situation of Wamena City

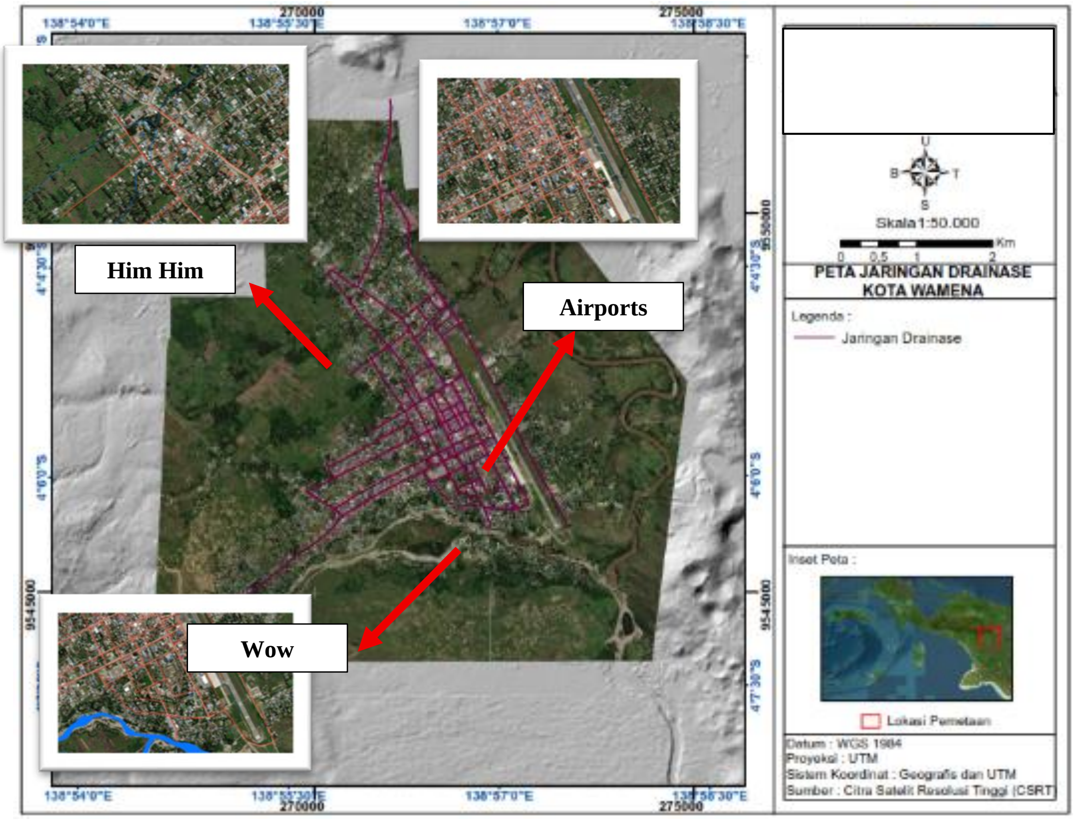

Figure 11. Map of Wamena City Drainage network

The drainage that flows directly into the Hetuma river is the drainage in the Hom-Hom area. The following are the results of hydrolomic and hydraulic analysis of drainage in the Hom-Hom area.

Table 9. Flood Discharge Hom Location

Period of project Ulang	Q (m3/det)
2	0.291
5	0.315
10	0.330
25	0.348
50	0.360
100	0.372

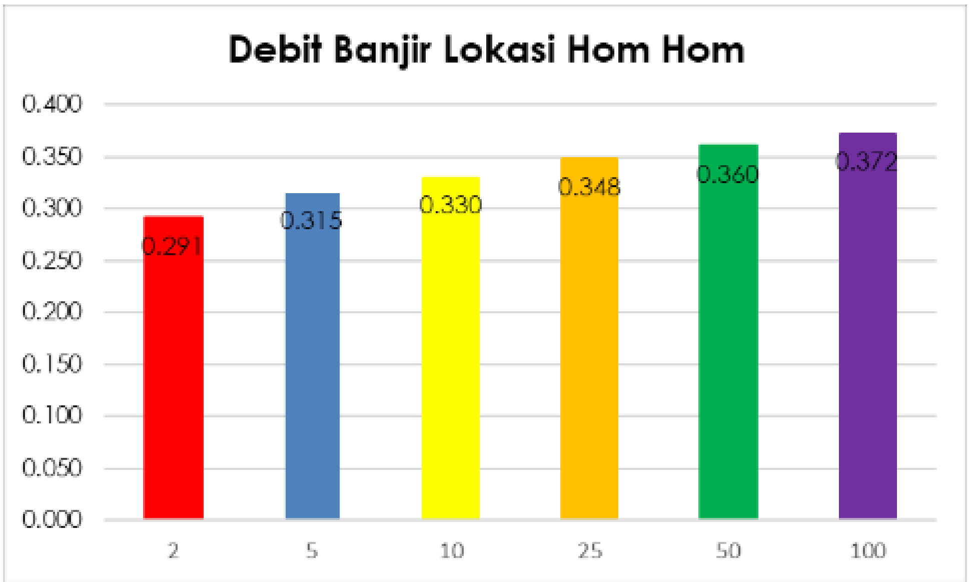

Figure 11. Flood Discharge Hom Location

At the Wouma location, there is also a lot of clogged drainage due to sediment that accumulates in several drains so that the ability of drainage to drain water is reduced, therefore flooding is inevitable. What needs to be done is to normalize the river and change the dimensions of the river. The following are the dimensions of the river that must be made based on the calculation of the planned flood discharge for drainage at the Wouma location.

Table 10. Calculation of Hydrological Discharge and Existing Cross-Section Capacity of Hom Hom Location Drainage

NO	Street Name	Shape Penampang	Construction Type	B (m)	b (m)	h (m)	m
1	JL. SD EXPERIMENT - HOM - HOM	Square	Plastered Stone Pairs	0.50	0.50	0.39	0.00
2	JL. SD EXPERIMENT - HOM - HOM	Square	Plastered Stone Pairs	0.50	0.50	0.05	0.00

NO	Street Name	Shape Penampang	Construction Type	B (m)	b (m)	h (m)	m
3	JL. HOM - HOM - FRONT OF YUDHA	Trapesium	Plastered Stone Pairs	0.80	0.70	0.66	0.67
4	JL. HOM - HOM - FRONT OF YUDHA	Trapesium	Plastered Stone Pairs	0.80	0.70	0.56	0.67
5	JL. HOM - HOM - AFTER BOX	Trapesium	Plastered Stone Pairs	0.80	0.70	0.66	0.67
6	JL. HOM - HOM - AFTER BOX	Trapesium	Plastered Stone Pairs	0.80	0.70	0.4	0.67
7	JL. HOM - HOM - JL. SANGER	Trapesium	Plastered Stone Pairs	0.80	0.50	0.1	0.67
8	JL. HOM - HOM - JL. SANGER	Trapesium	Plastered Stone Pairs	0.80	0.50	0.58	0.67

Table 11. Further Calculation of Hydrological Discharge and Existing Cross-Section Capacity of Hom Hom Location Drainage (With Sediment)

A (m^2)	P (m)	R (m)	S (%)	n	V (m/s)	Q (Hydraulics) (m^3/it)	Q (Hydrology) (m^3/it)	Control
0.195	1.280	0.152	0.008515	0.010	2.632	0.513	0.291	OK
0.025	0.600	0.042	0.008515	0.010	1.109	0.028	0.291	NORMALIZATION NEEDS TO BE DONE
0.752	2.428	0.310	0.008515	0.010	4.226	3.180	0.291	OK
0.601	2.187	0.275	0.008515	0.010	3.900	2.344	0.291	OK
0.752	2.428	0.310	0.008515	0.010	4.226	3.180	0.291	OK
0.387	1.803	0.214	0.008515	0.010	3.306	1.278	0.291	OK
0.057	0.841	0.067	0.008515	0.010	1.528	0.087	0.291	NORMALIZATION NEEDS TO BE DONE
0.514	1.995	0.258	0.008515	0.010	3.737	1.922	0.291	OK

At the Hom Hom location, there are also many clogged drains caused by sediment that accumulates in several drains resulting in reduced drainage ability to drain water, therefore flooding is inevitable. What needs to be done is to normalize the river and change the dimensions of the river.

CONCLUSION

Based on the research conducted on Analysis of the Effects of Land-Use Changes on Increased Flood Discharge in the Hetuma River Using a Hydrological Approach, it can be concluded that changes in land use, characterized by a reduction in forest areas and an increase in settlement areas, significantly increased the runoff coefficient. These changes resulted in several impacts, including increased peak flood discharge due to the expansion of impermeable surfaces and reduced infiltration capacity. Furthermore, the flow concentration time became shorter, causing flooding to occur more rapidly after high-intensity rainfall events. Overall, land-use changes were identified as a dominant factor contributing to increased flood discharge in the Hetuma River and a higher frequency of flood events in downstream areas.

The results also indicated that the drainage system in Wamena City had not functioned optimally due to limited channel capacity. Through the optimization modeling approach, several key findings were obtained. Drainage channels around the Hom-Hom area had insufficient capacity to accommodate actual runoff discharge, particularly in urban and low-lying areas. The optimization model demonstrated that increasing channel capacity and normalizing critical sections could significantly reduce inundation volume.

Based on the findings of this research, several recommendations are proposed to improve flood management efforts. Further planning and analysis are needed to strengthen flood control measures in the Hetuma River area. The Jayawijaya Regency Government and the Mountainous Papua Provincial Government should closely monitor land-use changes and implement appropriate land management strategies to prevent further increases in flood discharge.

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