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FLOOD MODELING AND ECONOMIC IMPACT ON FLOOD-PRONE RESIDENTIAL AREAS IN THE CILOSEH RIVER BASIN, TASIKMALAYA

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ABSTRACT

The Ciloseh River in Tasikmalaya City, West Java, spanning approximately 26.6 km with a 7,803-hectare catchment area, faces increasing flood vulnerability driven by rapid urban expansion and land-use conversion along its banks. This study systematically characterizes the river's floodplain morphology and quantifies potential economic losses from flooding across various return periods (2- to 50-year events). A comprehensive morphometric analysis of the watershed was conducted using Geographic Information Systems (GIS) to derive critical hydrological parameters. Flood discharge estimations were performed using the Synthetic Unit Hydrograph Gamma-I method. Hydrological data, augmented by field surveys, informed the development of a robust one-dimensional hydraulic model utilizing HEC-RAS software. The generated hydraulic model outputs were then integrated with high-resolution basemaps to produce detailed flood inundation maps. Economic loss assessments were rigorously performed following the ECLAC methodology, quantifying direct damages to infrastructure and residential properties. The analysis reveals significant flood inundation across all simulated return periods, with the 50-year event (Q50 = 473 m^3/s) leading to a substantial inundated area of 46,151 m^2, affecting 244 residential units, and incurring estimated economic losses of IDR 3,188,421,996 (approximately USD 200,000). These findings provide essential data for developing sustainable flood mitigation strategies, informing urban planning, and guiding resilient infrastructure design in rapidly developing riverine environments.

Keywords: *Flood risk assessment, Hydraulic modeling, HEC-RAS, GIS, Economic impact, Urban hydrology, River engineering*

1. INTRODUCTION

Rivers play a crucial role in the hydrological cycle. Rainfall that occurs over land will ultimately return to the sea through river systems. The volume or discharge of river flow is influenced by several factors, including precipitation intensity, land slope, and the size of the watershed area.

Flooding occurs when the water level in a river exceeds its normal capacity, typically resulting in overflow beyond the riverbanks and inundation of adjacent low-lying areas [1]. Flood events can have adverse impacts on human settlements, causing both material losses and non-material damages to the affected communities.

The Ciloseh River is one of the rivers located in the city of Tasikmalaya, West Java Province, Indonesia, with an approximate length of 26.6 km. The watershed area of the Ciloseh River covers approximately 7,803 hectares and forms part of the larger Citanduy River Basin [2]. Similar to other urban areas in Indonesia, the banks of the Ciloseh River have been utilized as residential areas by local inhabitants.

The rapid development of housing along the Ciloseh Riverbanks, which has not been accompanied by spatial planning and effective local government oversight, has increased the area's vulnerability to flooding, especially during periods of high river discharge. The lack of spatial information and data regarding flood-prone areas exacerbates the potential risks and can lead to greater socio-economic losses.

One of the efforts to mitigate the increasing risk of flooding is to understand the characteristics of the river floodplain [3]. The extent of the floodplain can be evaluated based on the morphological characteristics of the river's longitudinal and cross-sectional profiles. Furthermore, the delineated floodplain area can be overlaid with urban infrastructure maps using Geographic Information Systems (GIS) to assess potential damages and losses. This assessment can be conducted through the Damage and Loss Assessment (DaLA) methodology developed by the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC).

2. METHOD

Research Location

This research was conducted within a residential area along a 1-kilometer segment of the Ciloseh River, extending from the downstream section at the Simpang Lima Bridge (7°19'10.35" S, 108°13'13.03" E) to the upstream section near Jl. Tajur (7°18'15.76" S, 108°12'29.73" E). This river segment forms part of the Ciloseh Watershed (DAS Ciloseh), which exhibits a longitudinal morphology—broad in the upstream reaches and progressively narrowing toward the downstream sections. The total watershed area of the Ciloseh River, from the upstream boundary to the observation point, is approximately 64.233 km^2.

Data Analysis

Rainfall Data Consistency Test

Rainfall data used in this study must be evaluated for consistency, as changes during the measurement process may affect data reliability. Such changes can result from alterations in the surrounding environment,modifications in the specifications of the rain gauge, or relocation of the measurement station.

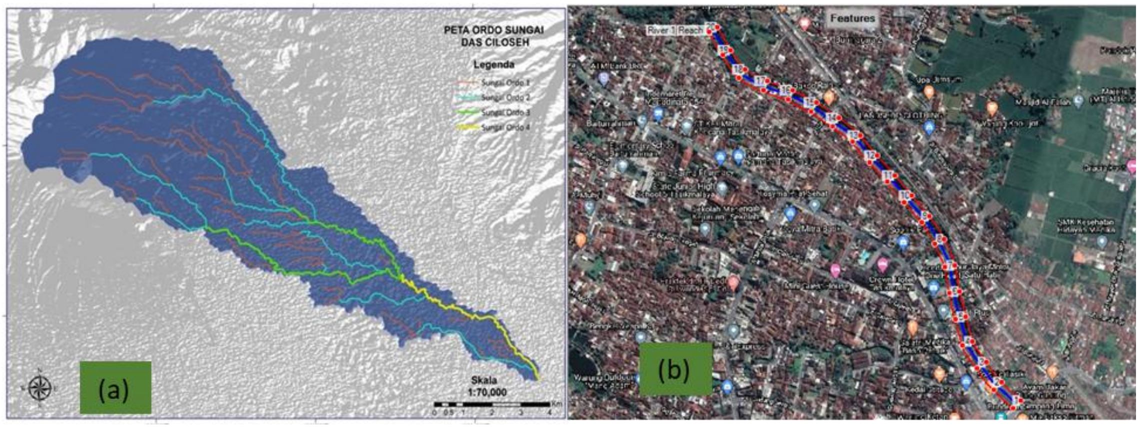

Figure 1. Research Area (a) Ciloseh Watershed, (b) Simulation Area

To assess the homogeneity of rainfall records, the Double Mass Curve (DMC) method is applied. This method helps identify inconsistencies or abrupt changes in the data series. If a significant deviation or breakpoint is detected, corrections must be made by referencing data from nearby rainfall stations with relatively stable historical records.

Areal Rainfall Estimation

Areal rainfall is estimated by calculating the average precipitation recorded at multiple rainfall stations located within the watershed area. Common methods used to determine the mean areal rainfall include the Arithmetic Mean Method, the Thiessen Polygon Method, and the Isohyetal Method. Each method offers a different level of accuracy depending on the spatial distribution of rainfall stations and the topography of the watershed.

Frequency Analysis

Frequency analysis is conducted to determine the probability distribution of daily rainfall data in relation to its annual average over a specified return period. Several statistical distribution models are commonly applied, including the Normal Distribution, Log-Normal Distribution, Gumbel Distribution, and Log Pearson Type III Distribution.

The selection of the most appropriate distribution model is based on goodness-of-fit tests and the statistical characteristics of the data, which are assessed using the following parameters: Skewness Coefficient (Cs), Kurtosis Coefficient (Ck), and Coefficient of Variation (Cv).

Goodness-of-Fit Tests

To determine the suitability of the selected probability distribution functions in representing the empirical rainfall data, goodness-of-fit tests are conducted. These tests compare the observed data distribution with the theoretical probability functions. In this study, two methods are employed: the Chi-Square Test and the Kolmogorov-Smirnov (K–S) Test. These statistical tools help validate the distribution model that best fits the rainfall data for further hydrological analysis.

Rainfall Intensity

The relationship between rainfall intensity (I), duration (D), and frequency or return period (T) is commonly expressed using an Intensity-Duration-Frequency (IDF) curve, which is developed from short-duration rainfall data (e.g., hourly) obtained from automatic rain gauges. The IDF curve is a critical tool in hydrologic and hydraulic design, including stormwater drainage systems, flood modeling, and the design of retention/detention basins.

In this study, the IDF curve was constructed using the Mononobe Method, an empirical approach widely applied in Indonesia for estimating design rainfall intensities. This method involves frequency analysis of short-duration rainfall records and expresses the IDF relationship in the form of the following equation:

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

Runoff Coefficient

The **runoff coefficient (C)** represents the ratio between the volume of surface runoff generated in a given area and the total volume of rainfall received over the same area [5]. It quantifies the portion of rainfall that becomes direct surface runoff and is influenced by factors such as land use, soil type, slope, vegetation cover, and rainfall intensity.

In general, surface runoff may be minimal if the rainfall intensity does not exceed the infiltration capacity of the soil. The runoff volume can be estimated using the following equation:

$$C_{DAS} = \sum_{i=1}^{n} \frac{C_i \times A_i}{A_i}$$

Flood Discharge Analysis

Nakayasu Synthetic Unit Hydrograph Method

The Nakayasu Synthetic Unit Hydrograph (SUH) method is widely used in Indonesia for estimating flood hydrographs in ungauged or data-limited watersheds. This empirical method allows for the approximation of peak discharge and hydrograph shape based on basic watershed parameters and rainfall input.

The peak discharge (Qp) using the Nakayasu method is calculated using the following fundamental formulation:

$$Q_p = \frac{A \cdot Ro}{3.6 \cdot \left(0.3 \cdot T_p + T_{03}\right)}$$

The value of peak discharge (Q_p) is influenced by several key parameters. Among these, the runoff coefficient (C) is commonly assumed to be 1.0 for design flood estimation in fully impervious or worst-case conditions. The watershed area (A) is expressed in square kilometers (km^2), while unit rainfall (Ro), representing the effective rainfall depth, is given in millimeters (mm).

Another critical variable is the time to peak (T_p), which refers to the time interval from the onset of rainfall to the occurrence of peak discharge. In addition, $T_{0\cdot3}$ denotes the recession time, or the duration required for the discharge to recede to 30% of the peak value following the flood peak. Both parameters, Tp and T0.3, are essential for constructing a complete hydrograph profile and for estimating flood duration and volume in hydraulic modeling.

Gama-I Synthetic Unit Hydrograph Method

The Gama-I Method is a synthetic unit hydrograph developed based on the hydrological behavior of 30 watersheds (DAS) in Java Island, Indonesia. This method is widely applied in Indonesia due to its empirical foundation and suitability for humid tropical watershed conditions.

The Gama-I Unit Hydrograph consists of three principal components:

1. Rising Limb – representing the increasing flow as rainfall runoff begins to concentrate.
2. Crest Segment – marking the peak discharge where inflow and outflow are nearly balanced.
3. Recession Limb – describing the gradual decline in discharge as the runoff diminishes over time.

Each segment of the hydrograph is mathematically defined to reflect typical response characteristics of Indonesian watersheds, making the Gama-I method a practical tool for flood estimation, especially in data-scarce or ungauged basins.

$$0 < t < TR \rightarrow Qt = \left(\frac{t}{TR}\right) \times Qp$$

$$t > TR \longrightarrow Qt = Qp \times e^{\frac{t}{k}}$$

$$TR = 0.43 \cdot \leq \left(\frac{L}{100SF}\right) + 1.0665 \cdot SIM + 1.2775$$
$$TB = 27.4132 \cdot A^{0.1456} \cdot S^{-0.9868} \cdot SN^{0.7344} \cdot RUA^{).2574}$$
$$Qp = 0.1836 \cdot A^{0.5885} \cdot TR^{-0.4008} \cdot JN^{0.2574}$$
$$K = 0.5617 \cdot A^{0.1798} \cdot S^{-0.1446} \cdot SF^{-1.0897} \cdot D^{0.0452}$$
$$Qt = Qp \cdot e^{-\frac{t}{k}}$$
$$Qb = 0.4751 \cdot A^{0.6444} \cdot D^{0.940}$$

In the **Gama-I hydrograph analysis**, several key parameters are used to define the temporal and volumetric characteristics of runoff response:

- **TRT_RTR** (rising time) refers to the time interval (in hours) from the onset of rainfall to the occurrence of **peak discharge (QpQ_pQp)**, which is measured in cubic meters per second (m^3/s). It represents the watershed's response time to effective rainfall.
- **TBT_BTB** (base time) denotes the total duration (in hours) of surface runoff generated by the rainfall event. It encompasses the complete hydrograph from rising limb to recession.
- **KKK** is the **storage coefficient** (in hours), representing the watershed's capacity to delay and attenuate runoff. It reflects the **retention and storage characteristics** of the catchment.
- **QbQ_bQb** is the **baseflow discharge**, measured in m^3/s. It accounts for the contribution of groundwater or other non-rainfall sources to the total streamflow and typically persists independently of rainfall events.
- **QtQ_tQt** refers to the **discharge during the recession limb** of the hydrograph, expressed in m^3/s. This value represents the gradually declining flow after the cessation of rainfall, characterizing the delayed runoff and baseflow return to pre-storm levels.

These parameters form the basis for constructing a realistic unit hydrograph in the Gama-I method, allowing for effective simulation of runoff response in tropical watersheds.

Snyder Synthetic Unit Hydrograph Method

The Snyder Synthetic Unit Hydrograph (SUH) method is an empirical approach used to estimate peak flood discharge by incorporating the physical characteristics of the watershed. This method is particularly useful for ungauged catchments, where limited or no streamflow data are available. It utilizes watershed parameters such as main stream length, basin area, and slope to generate a unit hydrograph that represents the typical runoff response to a unit depth of effective rainfall.

$$Q_p = \frac{C \cdot A \cdot R_0}{T_p}$$

Where:

- Qp = peak discharge (m^3/s)
- C = runoff coefficient (dimensionless)
- A = watershed area (km^2)
- Ro = effective rainfall depth (mm)
- Tp = time to peak (hours)

This formulation reflects the relationship between watershed response and rainfall input, allowing hydrologists to estimate flood magnitudes for design and risk assessment purposes, particularly in data-scarce regions.

The peak flood discharge (Q_p) in the Snyder Synthetic Unit Hydrograph method is estimated using an empirical formula that incorporates several key watershed parameters. These include the runoff coefficient (C), which typically ranges between 0.3 and 0.5, the catchment area (A) in square kilometers (km^2), the effective rainfall depth (R_o) in millimeters (mm), and the time to peak (T_p) in hours.

Flood Potential Analysis Using HEC-RAS

The HEC-RAS (Hydrologic Engineering Center's River Analysis System) model is employed to simulate one-dimensional steady or unsteady flow conditions in natural and constructed channels. The simulation results provide detailed information on the potential flood water surface elevations along each cross-section of the river channel.

The flood elevation at each section is determined based on the channel bed elevation and bank geometry, allowing the identification of maximum floodwater levels corresponding to specific design flood discharges for selected return periods [3]. This analysis enables the delineation of inundation zones and supports the planning of flood mitigation infrastructure and land use management.

Economic Loss Estimation Using the ECLAC Method

The assessment of disaster-related damage and loss in this study follows the methodology developed by the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC), commonly referred to as the ECLAC Damage and Loss Assessment (DLA) method. This approach is widely adopted in post-disaster evaluations across international contexts.

The ECLAC method provides a conceptual and methodological framework for estimating the physical damages to assets (capital stock) and the losses in the flow of goods and services due to disaster impacts. The analysis also considers temporary effects on key macroeconomic variables, such as GDP, inflation, employment, and public finances [6].

The ECLAC methodology enables a sectoral and comprehensive assessment, disaggregating impacts across affected sectors including infrastructure, housing, agriculture, and industry [7]. The general formulation for calculating disaster-related losses is expressed as:

$$K = n \times f_k \times NUP$$

Where:

- K = estimated economic loss (Rp),
- fk = **damage factor**, representing the degree of damage (dimensionless),
- n = **number or area of affected units**,
- **NUP** = **replacement unit value**, representing the cost per unit of asset replacement.

The affected area or number of impacted units (nnn) is derived from spatial analysis using Geographic Information Systems (GIS). The unit replacement value (NUP) is based on sector-specific loss valuation data from 2010, obtained from the Upper Citarum Basin Flood Management (UCBFM) database [8].

The analysis of flood-induced losses using the ECLAC methodology reveals a significant upward trend in damage values across all land-use categories when projected from 2010 to 2024. Among these, the industrial sector, particularly large and medium-scale industries, shows the most pronounced increase in economic losses compared to other sectors. Similar upward trends, though to a lesser extent, are observed in the household, agricultural, and road infrastructure sectors.

A further assessment of the relationship between flood depth and the flood damage factor (fk) across three land-use types—small-scaleindustry, infrastructure, and residential areas indicates a general increase in damage factor with rising flood depth. However, the rate of increase varies across sectors. Infrastructure assets exhibit the steepest increase in damage at low to moderate flood depths, highlighting their vulnerability to early-stage inundation. In contrast, household and small industrial sectors show a more gradual increase in damage, approaching maximum damage levels at depths of approximately 4 to 5 meters.

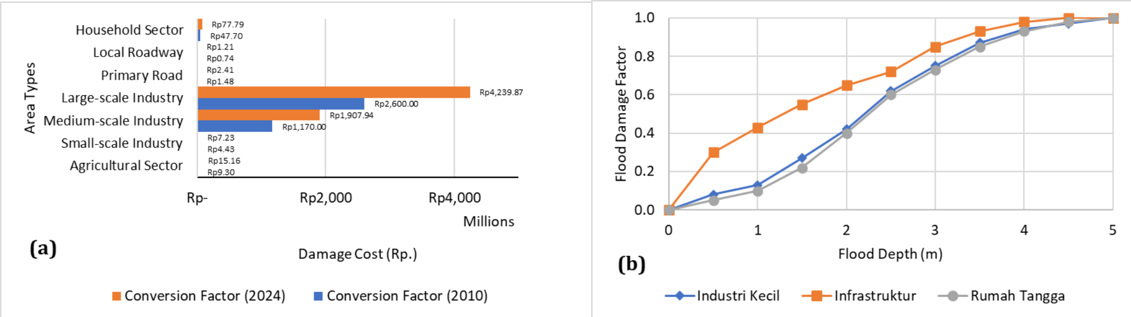

Figure 2. (a) Replacement Unit Value (b) Damage Factor

3. RESULTS AND DISCUSSION

Rainfall Data Consistency Test

The consistency of rainfall data was evaluated using the Double Mass Curve (DMC) method at three rainfall stations: Tejakelapa (a), Cimulu (b), and Cigede (c). The analysis was conducted over the period 2006–2016, by comparing each station's cumulative annual rainfall with the average rainfall recorded at surrounding reference stations (PCH Sekitar). Each graph displays the relationship between the cumulative rainfall of the test station and that of the surrounding stations, along with the applied correction line (PCH Koreksi).

Graph (a) illustrates a linear and consistent relationship between the Tejakelapa station and the surrounding stations, indicating that the data are homogeneous and require no correction. In contrast, graphs (b) and (c) exhibit noticeable deviations in the slope of the curve relative to the reference line, particularly after 2011. This deviation suggests changes in the rainfall recording pattern at the Cimulu and Cigede stations. Consequently, corrections were applied to the rainfall data at these two stations, as represented by the green correction curves, to reestablish a linear relationship aligned with the regional average pattern.

These findings indicate that the rainfall records at Cimulu and Cigede require statistical adjustment to achieve consistency with regional patterns. The consistency test results are illustrated in Figure 3.

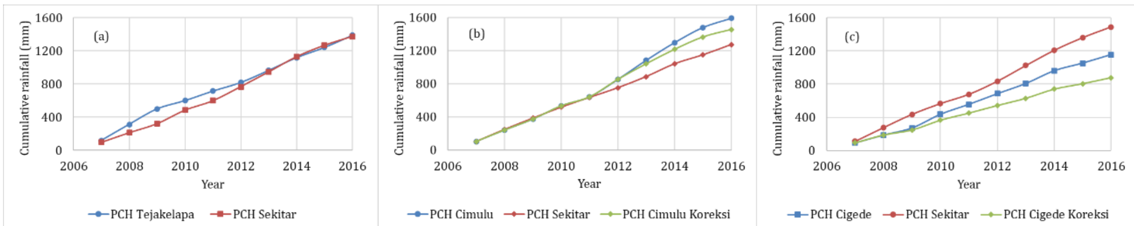

Figure 3. Consistency Graph of Rainfall Station (a) Tejakelapa, (b) Cimulu, and (c) Cigede

Regional Rainfall Analysis

Based on the regional rainfall distribution map generated using the Thiessen Polygon method, the catchment area is divided into three zones of influence corresponding to the rainfall stations (PCH): Tejakelapa, Cigede, and Cimulu. The respective area contributions are 48.724 km^2 (75.86%), 12.430 km^2 (19.35%), and 3.08 km^2 (4.79%). This indicates that the Tejakelapa station contributes dominantly to the regional rainfall estimation, covering more than three-quarters of the total catchment area. In contrast, the Cigede and Cimulu stations, although covering smaller areas, remain significant in capturing the spatial variability of rainfall, particularly in the downstream and eastern parts of the region.

These area-based weightings serve as the basis for calculating a representative average regional rainfall, where the proportional area associated with each station directly influences the final result of the areal rainfall computation.

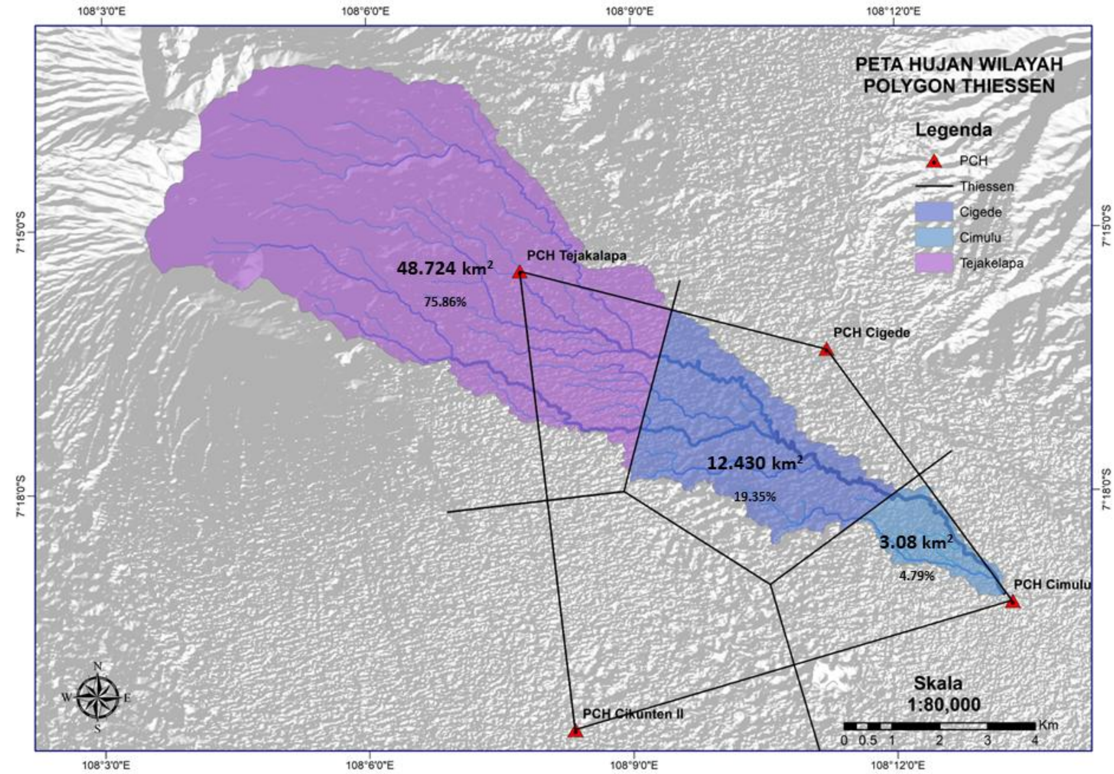

Figure 4. Thiessen Polygon of Ciloseh Watershed

From the three rainfall stations, straight lines were drawn to connect each pair of stations in order to delineate the area of influence for each PCH (Pos Curah Hujan). The influence zones were determined by constructing perpendicular bisectors to the connecting lines between stations, resulting in distinct Thiessen polygons for each station. This spatial partitioning highlights the dominant contribution of the Tejakelapa station to the areal rainfall calculation.

The dominance of Tejakelapa is evident in the areal rainfall trends: when rainfall at Tejakelapa increases (as observed in 2008 and 2009), the regional rainfall also shows a significant rise. Conversely, even when rainfall at other stations such as Cimulu is relatively high, its impact on the overall catchment rainfall remains limited due to its smaller area of influence. The areal rainfall distribution for the Ciloseh watershed is illustrated in Figure 6a.

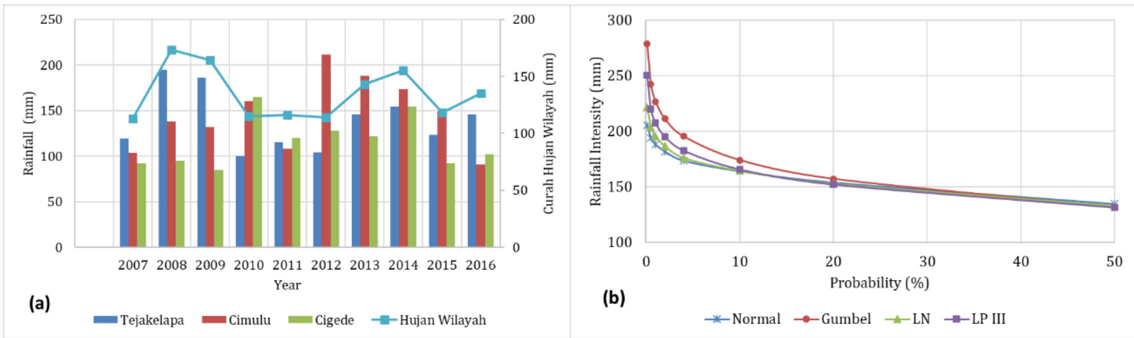

Figure 5. Regional Rainfall Graph (a), design rainfall intensity graph (b)

Frequency Analysis and Rainfall Distribution Testing

The frequency distribution analysis aims to determine the design rainfall magnitude based on specific planning criteria. The analysis was conducted using rainfall return periods of 2, 5, 10, 25, 50, 100, 200, and 1000 years. The results indicate that the four statistical distribution methods employed yield varying rainfall intensity values corresponding to different probabilities of occurrence.

In general, all methods demonstrate an increase in rainfall intensity as the probability of occurrence decreases. However, differences are observed in the rate of increase and the intensity values at specific probabilities. Among the methods, the Gumbel and Log Pearson Type III (LP III) distributions exhibit higher trend lines, indicating greater intensity values for lower probabilities, compared to the Normal and Log-Normal distributions. This suggests that Gumbel and LP III may be more appropriate for characterizing extreme rainfall events in the study area.

Despite this, statistical goodness-of-fit testing indicates that only the Log Pearson Type III distribution satisfies the required criteria. Consequently, this distribution was selected for use in the design rainfall intensity estimation. The analysis results are presented in Figure 6b.

Distribution Goodness-of-Fit Test

Following the selection of the appropriate distribution, it is essential to evaluate its goodness-of-fit to the empirical frequency distribution using statistical tests. In this study, the Chi-Square Test and the Kolmogorov–Smirnov (K–S) Test were applied.

The Chi-Square Test yielded a calculated value of $X^2 = 1$, which is less than the critical value $X^2_a = 5.991$ at a 5% significance level, indicating that the observed and expected frequencies are statistically consistent. Similarly, the K–S Test resulted in Dmax = 0.202, which is lower than the critical value Dcr = 0.409 at the same significance level.

Based on these results, the Log Pearson Type III distribution is considered statistically acceptable and appropriate for modeling the frequency distribution of rainfall in the study area.

Rainfall Intensity Analysis

In this study, a rainfall duration of 6 hours was used, corresponding to the typical storm durations observed on the island of Java, which generally range between 6, 8, or 12 hours based on hourly rainfall records from monitoring stations. To estimate short-duration (hourly) rainfall intensity, both the Modified Mononobe method and the Alternating Block Method (ABM) were applied. The results of the calculations are presented in Figure 6.

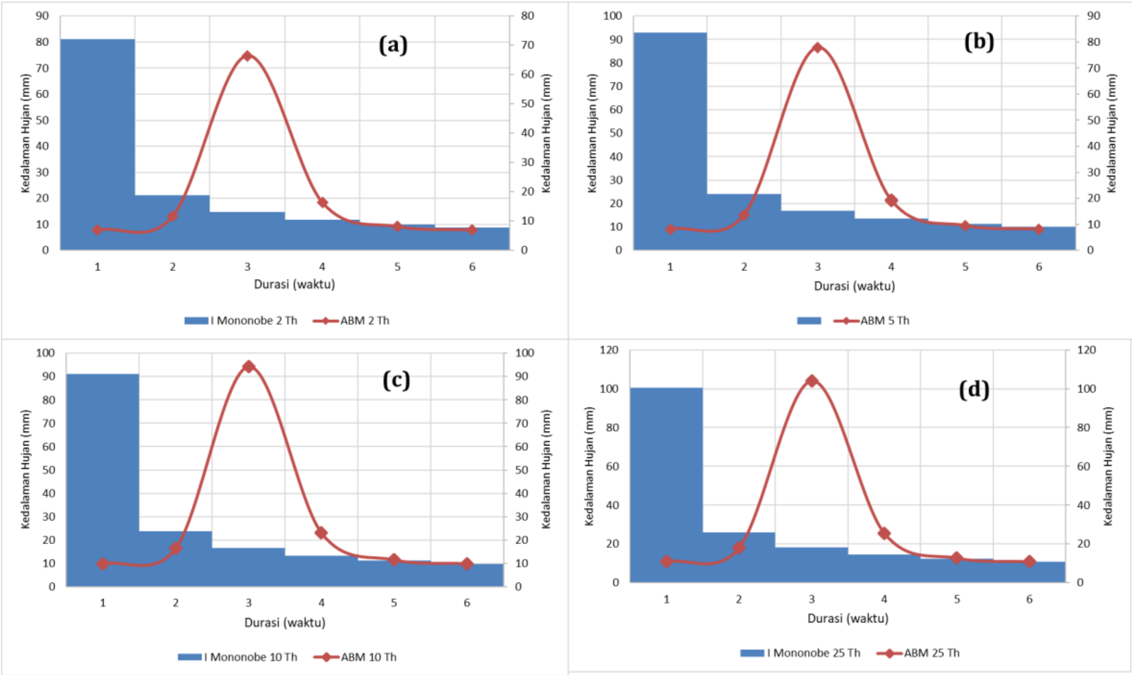

Figure 6. IDF Curve (a) 2 Year return period, (b) 5 Year Return Period, (c) 10 year Return Period, and (d) 25 Year return Period

Land Use Analysis and Surface Runoff Coefficient in the Watershed

Based on land cover data, the study area is predominantly occupied by rice fields, covering 2,681.4 hectares or approximately 41.8% of the total area, indicating a high intensity of wetland agricultural activities. Industrial forest plantations account for 24.8% of the area, followed by dryland agriculture at 11.3%, and residential areas at 9.3%, reflecting a mix of agricultural land use and built-up area development. Other land cover types, such as secondary dryland forest, shrubs/bushes, open land, and water bodies, contribute less significantly to the total land area.

Higher runoff coefficient (C) values are associated with residential and agricultural land, with respective values of 0.7 and 0.3, indicating a greater potential for surface runoff due to their lower infiltration capacities. In contrast, land cover types such as secondary forest, plantation forest, and water bodies exhibit lower C values, reflecting their better hydrological function in terms of rainwater absorption.

Rice fields represent the largest land cover area with the highest contributing area (A), whereas water bodies account for the smallest land area. Based on the total watershed area of 64.22 hectares and the spatial distribution of varying runoff coefficient values, the average watershed runoff coefficient (C_{DAS}) was calculated to be 0.18.

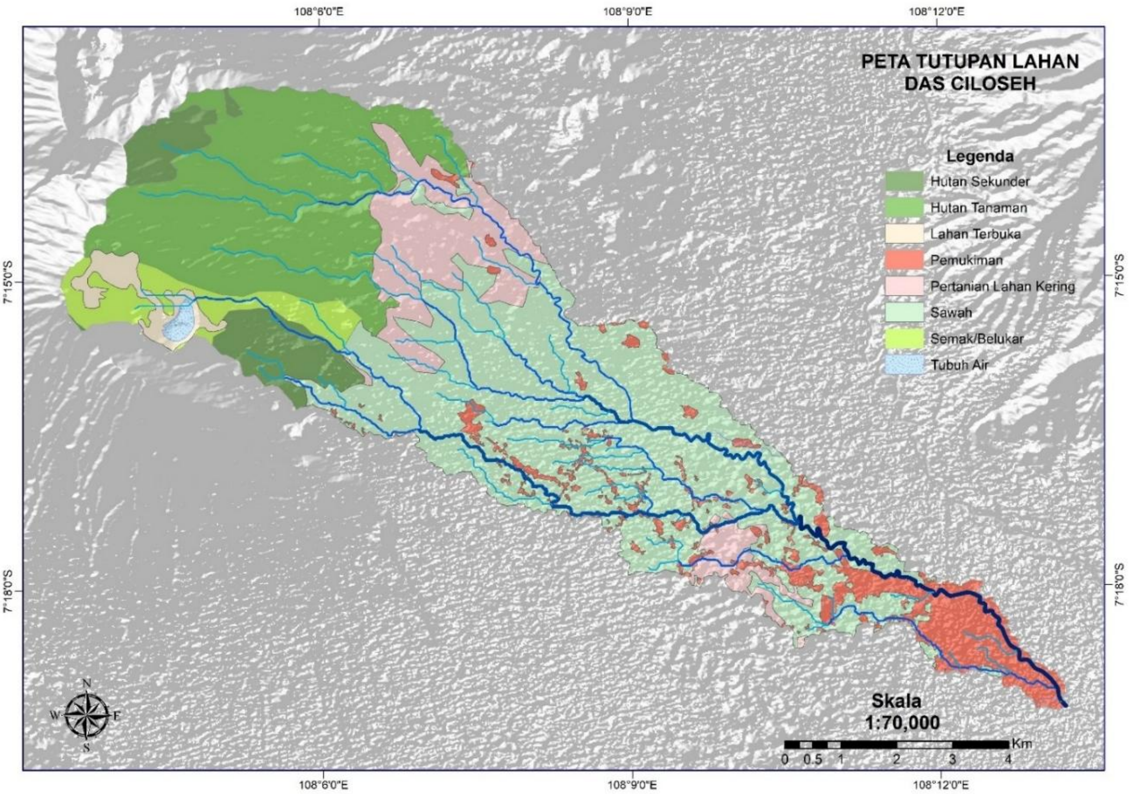

Figure 7. Land Use Map of Ciloseh Watershed

Design Flood Discharge Analysis Using Nakayasu, Gamma I, and Snyder Methods

Synthetic Unit Hydrograph (SUH) methods—Nakayasu, Gamma I, and Snyder—were applied to estimate peak flood discharge for return periods (PUH) ranging from 2 to 50 years. Among the three methods, the Gamma I method consistently produced the highest peak discharge values across all return periods, with a maximum discharge of 472.935 m^3/s for the 50-year return period. This indicates that the Gamma I method tends to provide a more conservative estimate of potential flood magnitudes.

The Nakayasu method yielded more moderate peak discharge values, while the Snyder method produced the lowest peak discharges in comparison to the other two. These variations highlight the differing sensitivities of each method to watershed morphometric parameters and the characteristics of the design rainfall input.

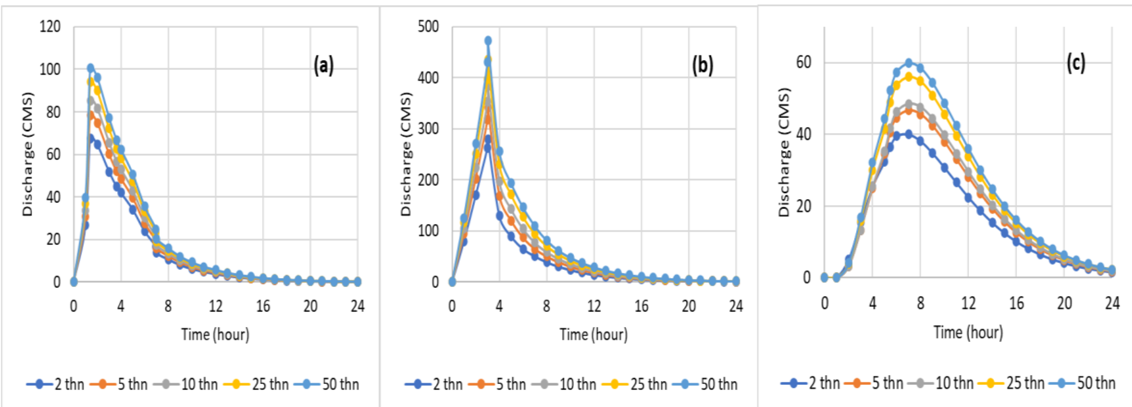

Figure 8. Synthetic Unit Hydrograph (a) Nakayasu, (b) Gamma I, and (c) Snyder

Flood Inundation Modeling Analysis

The subsequent step in the flood simulation modeling involved using the design discharge values for various return periods, based on the peak flow estimated from the Gamma-I Synthetic Unit Hydrograph (SUH). The peak discharge was observed at hour 3.02 along the surface flow of the Ciloseh River. This discharge was then input into the HEC-RAS software as a steady flow condition.

The simulation results provided detailed information on the potential flood water surface elevation at each river station (STA), calculated relative to the riverbed and bank elevations. From this, the maximum flood water surface elevation corresponding to the design flood discharge for each return period was determined.

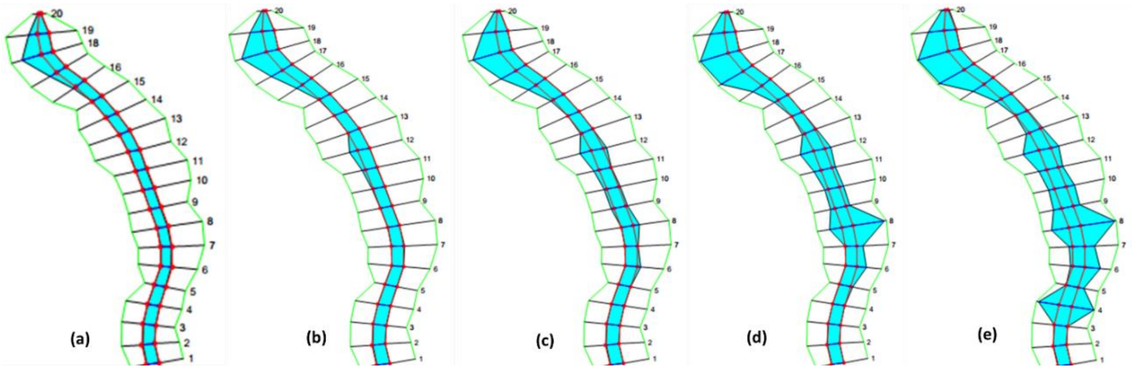

Figure 9. Simulation Result of The Ciloseh Cross Section (a) 2 year return period, (b) 5 year return period, (c) 10 year return period, (d) 25 year return period , and (e) 50 year return period

Based on Figure 9, potential flood inundation is observed between STA 19 and STA 16 for the 2-year return period. The extent of inundation increases progressively for the 5-year, 10-year, and up to the 50-year return periods. Additional inundation points emerge for return periods beyond 10 years, indicating a substantial flood risk along the floodplain of the Ciloseh River.

This condition signifies a high flood vulnerability, particularly given that the affected areas are situated within a densely populated region. As such, the associated flood hazard poses considerable risk to both the built environment and the local community.

Flood Loss Estimation

Following the flood potential analysis along the Ciloseh River using the HEC-RAS model, flood depth and inundation extent in the surrounding areas were determined. To identify the specific areas affected by flooding, elevation data were adjusted using contour information derived from a Digital Elevation Model (DEM). This data was then overlaid with a basemap using Geographic Information System (GIS) software to accurately identify and delineate inundated features and assets within the floodplain.

Figure 10. Flood Inundation of the Ciloseh river (a) 2 Year Return Period, (b) 5 Year Return Period

Figure 11. Flood Inundation of the Ciloseh river (a) 10 Year Return Period, (b) 25 Year return Period, (c) 50 Year return Period

Once the flood inundation extent and the number of affected objects were identified, flood losses were estimated using the ECLAC (Economic Commission for Latin America and the Caribbean) methodology. The analysis indicates that inundation occurs across all return periods.

For a 2-year return period (Q2), flooding affects the area between STA 16 and STA 20 with an inundated area of approximately 4,856 m^2. At Q5, the flooded area in the same segment increases to 5,982 m^2. For Q10, the inundation expands from STA 8 to STA 20, covering 18,236 m^2. At Q25, flooding occurs from STA 6 to STA 20, affecting an area of 27,947 m^2. The most extensive inundation is observed at Q50, covering STA 3 to STA 20, with a total inundated area of 46,151 m^2.

Further details on the affected sectors and the estimated economic losses for each return period are presented in Figure 12.

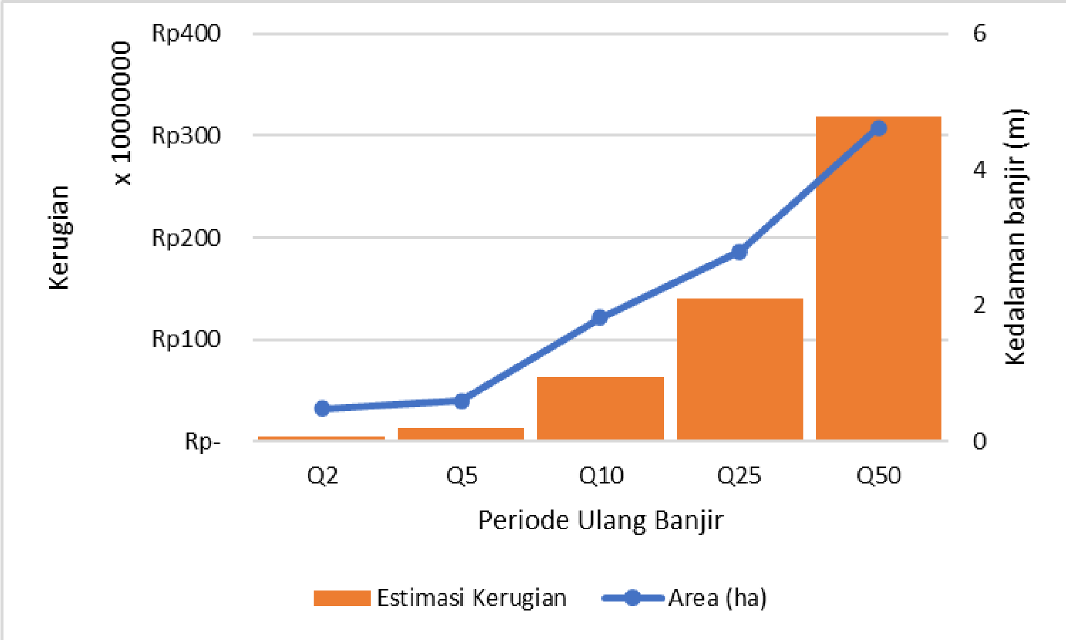

Figure 12. Estimated Economic Losses and Flood Depth for Various Flood Return Period

4. CONCLUSION

Based on the analysis results, the peak flood discharge estimated using the Gamma I Synthetic Unit Hydrograph (SUH) method exhibits a significant upward trend with increasing return periods, reaching a maximum of 472.935 m^3/s for the 50-year return period (Q50). The hydrodynamic simulation using HEC-RAS, combined with spatial analysis, reveals an expanding flood inundation area in line with longer return periods, reaching up to 46,151 m^2 at Q50.
Furthermore, economic loss estimation in residential areas along the banks of the Ciloseh River, carried out using the ECLAC method, also indicates a sharp increase in potential damages. The highest estimated loss reaches IDR 3.18 billion for the 50-year return period, highlighting the substantial flood risk faced by the community in this densely populated floodplain.

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