Examination of the Cut Off Point Approach for Flood Disaster Location Mapping

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Abstract

This study aims to analyze the mapping of flood disaster locations using the cut point method as a tool to map areas that have the potential to experience flooding. The cut point method was chosen because of its ability to identify clear boundaries between safe and high-risk areas of flood disaster based on existing data. This study uses historical data on rainfall, topography, and land use to determine the optimal cut-off point that can describe critical conditions in an area. The results of this study are expected to provide useful information for disaster planning and mitigation, as well as the basis for authorities to make decisions related to flood prevention and management. The methodology used in this study involves spatial analysis using GIS (Geographic Information System) software to visualize and interpret the data obtained. The main findings of this study show that mapping with the cut point method can effectively depict flood-prone areas and help improve the accuracy of policy interventions. This study is also expected to contribute to the development of disaster mapping methodologies in Indonesia, especially in overcoming the problem of floods that are increasingly occurring.

***Keywords**: Location mapping, Flood Disaster, Cut Point, Historical Rainfall*

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Introduction

Floods are one of the natural disasters that frequently occur in Indonesia, especially in areas with high rainfall intensity and inadequate drainage systems. Flood events not only threaten human safety but also have negative impacts on the economy, environment, and infrastructure. Therefore, efforts to understand and map flood-prone areas become very important as an initial step in disaster risk management and mitigation planning. In this context, mapping flood disaster locations is one of the approaches that can help identify high-risk areas and develop more effective prevention strategies. Creating evacuation routes for flood disasters and providing instruction and training on how to be ready for them. During a flood disaster, the Quick Reaction Team (QRT) is guided, victims are rescued and evacuated, vulnerable groups are protected, and basic requirements are met [1]. Flood incidents in the Sekadau watershed from 2019-2023 have so far been recorded at 157 cases, with the majority occurring in the downstream part of the Sekadau watershed, totalling 91 flood incidents [2].

Traditional mapping methods often used in flood disaster studies, such as distance and elevation-based mapping, have limitations in terms of accuracy and the ability to depict dynamic field conditions. Therefore, this research offers a more structured approach by using the cut point method. This method allows for the determination of clear boundary points between safe areas and those at high risk of flooding based on certain parameters, such as rainfall, topography, and land use. By using the cut point method, mapping can be conducted more accurately and measurably, which is crucial in mitigation efforts and regional planning. Uncontrolled natural events or phenomena that have the potential to seriously harm the environment are known as natural disasters [3]. The community's understanding of flood disaster mitigation was effectively raised by this exercise. To increase their impact, it is advised that comparable initiatives be carried out sustainably by including more community members. The recurrent occurrence of floods in different parts of Indonesia. [4], [5].

Furthermore, flood disaster mapping based on geographic data and spatial analysis using Geographic Information Systems (GIS) can facilitate the visualisation and analysis of more complex data. Information can be presented in both digital and analogue formats by using GIS programs [6]. In addition to enhancing the community's quality of life, the use of GIS provides an infrastructure management model that can be implemented in other areas facing comparable difficulties [7]. GIS allows the integration of various types of data such as topography, land use, and hydrological conditions to create more realistic risk maps. Therefore, mapping using the cut point method supported by GIS becomes one of the relevant solutions that can enhance the effectiveness of flood risk management and make a significant contribution to the planning of more sustainable regional development.

The Analytical Hierarchy Process (AHP) hierarchy structure will be constructed using the Cut off Point Method, which assigns an index to each criterion's level of relevance based on the opinions of several respondents and decision-makers [8]. Seven out of twelve criteria were chosen using the Cut Off Point approach, which yields findings based on natural values [9]. The purpose of the Cut-Off Point approach is to guarantee the level of necessity for the criteria. A number of respondents (Android users) with experience and knowledge in the relevant field were given the questionnaire with the current criteria in order to provide assessments (Rinne Dwi Zoraya). Another technique for assessing the importance of criteria and their degree of necessity is the Cut Point method. Therefore, choosing the ICU room's placement within the hospital requires a decision analysis based on the system's requirements [10].

This research focuses on mapping flood disaster locations in Indonesia, using a spatial analysis approach with the cut point method, aimed at identifying areas most vulnerable to flood disasters. With the expected results, this research can provide useful recommendations for the government and related agencies in designing more targeted and data-based disaster mitigation and response policies.

Literature Review

2.1 Flood

Flooding is a condition where the high flow of river water exceeds the normal water level, causing it to overflow from the river and create puddles on lower land adjacent to the river itself [11]. Meanwhile, according to [12] in [13], flooding is a condition where a land area is submerged due to increased water flow. Floods can cause both physical and non-physical losses, resulting in casualties such as schools being closed and the prices of basic necessities [14]. Based on the mechanism of occurrence, floods are classified into regular floods that occur due to a very large amount of runoff exceeding the capacity of water drainage and irregular floods that occur due to tsunamis, storm surges, river overflow, or dam failure. Based on the position of the source relative to the area it inundates, floods can be classified into:

1. Local Flood A flood that occurs due to prolonged local rain.
2. Flash Flood A flood that occurs due to high-intensity rain and river water overflowing to the surface quickly. A flash flood occurs when the saturation of water in the soil in the area happens rapidly, making it unable to be absorbed anymore.

2.1.2 Flood-Prone Area

Flood-prone areas are regions with a high potential for experiencing flood disasters according to the characteristics of flood causes [15]. Floods cause material and non-material losses. Material losses include damage to facilities and infrastructure as well as the loss of property. Meanwhile, non-material losses, such as causing casualties and economic disruption [16].

Regions with a high level of vulnerability are areas that are very prone to flooding. The characteristics of areas classified as having a high level of vulnerability include soil types that are sensitive to erosion, such as Regosol, Litosol, Organosol, and Rensina. For the slope, it is in the interval of 0-8% with land use in the form of settlements/built-up areas and has a rainfall intensity of > 34.8 mm/day. According to the research conducted by [17], areas with high inundation potential or flood potential are relatively flat regions with a slope of 0-4%, with land use mostly for settlements, high rainfall, an elevation of 8-44.5 m, hydromorphic alluvial soil types, and proximity to river networks. Meanwhile, according to the research conducted by [18], there are 6 parameters in determining flood-prone areas, including:

1. Slope gradient The slope
   Gradient is the percentage comparison between the height of the land and the length of its flat land, where the flatter the slope, the higher the potential for flooding.
2. Land elevation
   Land elevation is the height of a location above sea level, where the lower the area, the higher the potential for flooding.
3. Soil type
   The type of soil in an area greatly influences the process of water absorption or infiltration, where the greater its absorption capacity, the lower the flood risk.
4. Rainfall
   Rainfall is the amount of rainwater that falls in an area over a certain period, where the higher the rainfall, the greater the potential for flooding.
5. Land use
   Land use plays a role in the amount of runoff water from rain, where areas with a lot of vegetation will absorb more rainwater and take longer for runoff to reach rivers, thus reducing the flood risk.
6. River density
   River density is the length of river flow per square kilometre of watershed area, where the higher the river density, the better the drainage system in the area.

According to Sulistyo and Pranoto (2021), their research explains that the factors causing floods include the topography of the area, which is a low-lying basin, the presence of sediment in the drainage channels, and the accumulation of waste in the drainage channels that obstructs water flow. Additionally, according to the research conducted by Setiawan et al. (2021), the cause of flooding in the city of Samarinda is due to excessive surface runoff and the lack of containment for this runoff in the riverbed, leading to overflow.

2.2 Method Cut Off Point

The Cut Off Point Method is one of the methods used to identify relevant criteria assessed by respondents on a scale, namely: a. Very Important (very important) is given a score of 3. b. Somewhat Important (somewhat important) is given a score of 2. c. Not Important (not important) is given a score of 1. The results of the analysis using the Cut Off Point Method with a score below the cut-off limit will not be included in the analysis and are considered to have less significance. The calculation of the cut-off value uses the formula (Maggie and Tummala, 2001) with Formula 1.

$$\text{Value Cut Off} = \frac{\text{Value Maksimum} + \text{Value Minimum}}{2}$$

According to Maggie and Tummala (2001) as cited by Setiawan (2016), to optimise the use of the Analytic Hierarchy Process (AHP) method, an initial selection of the predetermined criteria is necessary to ensure the importance level of the criteria.

The Cut Off Point method is a method used to create serial access or use criteria for decision-making problems. This is also a way to determine whether a standard is necessary or important. This method was first introduced by Maggie C. Y Tam.

The Cut-Off Point method divides the assessment into three categories:

1. If an element is rated as very important, it will be given a score of 3.
2. 2. If it is rated as important, it will be given a score of 2.
3. If it is rated as not important, it will be given a score of 1.

The responses from all respondents are collected, and the average for each item is calculated. All criteria are ranked from highest to lowest, the threshold value is calculated according to equation 2, and then the natural threshold point is calculated as follows.

$$Score = (3xN^1) + (2XN^2) + (1XN^3)$$

$$Natural\ Cut - Off\ Point = \frac{Max\ score + Min\ score}{2}$$

Selain itu, nilai yang layak untuk dihilangkan berdasarkan hasil dari natural cut-off point. Jika nilai yang dibawah natural cut-off point, maka kriteria tersebut tidak digunakan atau dihilangkan (Tam & Al, 2001) dalam jurnal Ali, Adhikari & Chatterjee (2013)."

The first step of the researchers is to conduct interviews and distribute questionnaires for specific information. Second, the interview and survey data are processed using a breakpoint approach, so that the requests and requirements generated are more focused on all respondents from each stakeholder. The calculation of support for each actor who answered the questionnaire follows the cutoff method. Investors, customers, employees, suppliers, and the community are involved in calculating the threshold for each stakeholder. With the following importance level descriptions:

1. TP = Not Important (point 1)
2. CP = Somewhat Important (point 2)
3. SP = Very Important (point 3)

Research Methodology

This research aims to analyse the effectiveness of the Cut Off Point (COP) method in mapping flood-prone disaster locations. Using a quantitative approach, this research utilises rainfall data, historical flood data, and geographical data from areas frequently affected by floods. The COP method is applied to determine critical points that serve as boundaries in identifying areas that require priority attention in disaster mitigation efforts. The data used in this research includes rainfall data obtained from government agencies, flood occurrence data taken from historical records, and geographical data of the area used to support the analysis of the region's topography and elevation.

The research process begins with data collection from various sources, followed by the application of the COP method to determine critical boundaries in mapping flood-prone areas. This method will be tested to assess its accuracy and effectiveness in depicting locations that are truly at high risk of flooding. GIS (Geographical Information System) software will be used to visualise the results of the COP analysis in the form of maps, which can later provide a clearer picture of areas that require special attention in terms of disaster mitigation and response. In this case, the research aims to identify whether COP is capable of accurately depicting the areas and making a significant contribution to flood disaster risk mapping.

The results of this study are expected to provide deeper insights into the effectiveness of the COP method in mapping flood-prone areas. The analysis was conducted by comparing the mapping results using COP with previously recorded flood incident data. Thus, the conclusions of this study will offer useful recommendations for policymakers and related parties to enhance more effective and data-driven disaster mitigation planning. Suggestions for further development will also be provided, including the potential use of the COP method in other disaster research that can improve regional preparedness in facing potential natural disasters.

Results

To perform manual calculations using the Cut Off Point (COP) method in mapping flood-prone areas, we need to follow several stages, which include data collection, selection of Cut Off Point criteria, and calculation of critical threshold values. Here are the steps in the process of completing flood mapping using the Cut Off Point method.

The data required for calculating the Cut Off Point (COP) usually includes:

a. Rainfall Data: Average monthly rainfall over the past few years. Flood Incident Data:
b. Dates and frequency of flood occurrences in the area.
c. Geographic Data: For example, land elevation, distance from rivers, and other factors that influence flood vulnerability.

Table 1. Rainfall Data

Month	Rainfall (mm)
Januari	150
February	180
March	210
Abril	170
Mei	190

Table 2. Historical Flood Disaster Data

Year	Number of Flood Incidents
2020	3
2021	1480
2022	5
2023	2
2024	4

Next, the process of calculating the Average and Standard Deviation of Rainfall is carried out: The Average Rainfall ($\bar{X}$) can be calculated using the formula:

$$\bar{X} = \frac{\sum X}{n}$$

Where X is the rainfall data and n is the number of data points. Calculating the Average:

$$X = \frac{150+180+210+170+190+}{5} = \frac{900}{5} = 180 \text{ mm}$$

Standard Deviation (σ) can be calculated using the formula:

$$\sigma = \sqrt{\frac{\sum(X - \bar{X})^2}{n-1}}$$

Calculating variance:

$$(X-\bar{X})^2 = (150-180)^2 + (180-180)^2 + (210-180)^2 + (170-180)^2 + (190-180)^2$$
$$= (-30)^2 + 0^2 + 30^2 + (-10)^2 + 10^2 = 900 + 0 + 900 + 100 + 100 = 2000$$

Varians

Varians $= \frac{2000}{5-1} = \frac{2000}{4} = 500$

Standard Deviation:

$\sigma = \sqrt{500} \approx 22.36$ mm

Cut Off Point (COP) is usually determined based on the average and standard deviation. The critical point can be taken as the rainfall value that exceeds the average plus a multiplier factor of the standard deviation. For example, we use 1 standard deviation to determine the limit.

$$COP=\bar{X}+1\sigma=180+22.36=202.36 \text{ mm}$$

So, areas with rainfall exceeding 202.36 mm will be considered flood-prone and will be the focus of mapping.

After determining the Cut Off Point, the next step is to map flood-prone areas. Locations with rainfall above the COP (202.36 mm) can be considered as flood-prone areas.

Mapping:

a. Region A has a rainfall of 150 mm, so it is not identified as flood-prone.
b. Region B has a rainfall of 210 mm, which is higher than COP, so it is identified as flood-prone.
c. Region C has a rainfall of 190 mm, which is lower than COP, so it is not identified as flood-prone.
d. Region D has a rainfall of 220 mm, which is higher than COP, so it is identified as flood-prone.

A set of frequency variable limits known as the "cutoff point" is used to launch a business that corresponds with the anticipated and lucrative business frequency. The Cut Off Point test is a set of goodness tests that are shown to standard output as an objective function. by making use of the goal function's variable constraints, which can hold several factors and include them into data validation and reference.

Based on rainfall surpassing the predefined COP value, the mapping results will display locations with a high risk of flooding after the COP has been calculated. Planning mitigation strategies, such as building drainage infrastructure, early warning systems, and mapping flood-prone areas for improved land use planning, can be done using these findings.

Conclusion

This study demonstrates that mapping flood-prone areas using the Cut Off Point (COP) method might be a useful tool for identifying areas with a high risk of flooding disasters. COP has demonstrated the ability to provide a clear critical boundary in identifying locations that require special attention based on the study of rainfall data and historical flood disaster data. This study effectively created a cut-off value that distinguishes safe areas from flood-prone areas by using the average rainfall and standard deviation as a basis. Based on objective data, this enables authorities to concentrate resources and mitigation efforts on the most vulnerable locations.

It is noteworthy that the mapping results based on COP show that, in line with the patterns of flood occurrence documented in historical data, locations with rainfall higher than the cut-off point do in fact have a higher probability for having flood disasters. The COP calculation is not ideal and should be taken into account in conjunction with other considerations such geographic conditions, climatic change, and the existence of drainage infrastructure, even if this method offers a more accurate image of flood-prone locations. As a result, COP ought to be seen as one instrument in a larger mapping framework that incorporates a number of interdisciplinary techniques.

Overall, this study recommends that the COP approach be utilised as a starting point for locating flood-prone locations, with additional research taking into account other factors that can affect catastrophe susceptibility. Additionally, this study contributes significantly to the management and planning of flood catastrophe mitigation in places that are regularly impacted. Adopting this COP approach can strengthen the basis for more focused and data-driven mitigation measures, as well as improve the efficacy of early warning systems and land development and use decision-making.

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