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Detecting the Distribution of Flood Inundation in Sunggumanai Village, Pattallassang District, Gowa Regency Using Sentinel-1 Synthetic Aperture Radar (SAR)

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A B S T R A C T

Satellite imagery technology is very useful for monitoring flood disasters in Indonesia. Satellite imagery captures images of the Earth's surface from space. Synthetic Aperture Radar (SAR) is one type of satellite imagery that can be used to detect flooding in Indonesia. The advantage of Sentinel imagery is the use of radar waves in the recording process, so it can map areas inundated by floods during periods of high cloud cover. Sunggumanai Village, Pattallassang District, Gowa Regency, is one of the villages frequently hit by floods, causing several families to evacuate. The technique used to detect floods is the thresholding method. This method is used to separate land and standing water using the Sentinel Application Platform (Snap). The data used includes three scenes of Sentinel-1 synthetic aperture radar satellite imagery: before the flood, during the flood, and after the flood. Based on the results of the study, the area affected by the flood was approximately 54% of the total area of Sunggumanai Village, or 264 hectares of the total area of 487 hectares. The affected area is largely productive agricultural land. An accuracy evaluation was conducted to determine the accuracy of the remote sensing results. Overall accuracy test results showed that the synthetic aperture radar achieved 75% accuracy in detecting floodwater distribution

INTRODUCTION

Satellite imagery technology is highly useful for monitoring flood disasters in Indonesia. Satellite imagery represents a depiction of the Earth's surface, captured by satellites from space (Nasution & Nurtyawan, 2020). The National Disaster Management Agency (BNPB) notes that several factors contribute to flooding, including topographic conditions, overflowing river basins, and high rainfall intensity. Currently, high rainfall intensity is a key factor in flooding. According to data from the Pattallassang District Office, flooding is a frequent occurrence in Pattallassang District, Gowa Regency. One of the main causes of flooding in this region is the high rainfall intensity and the location of the area within the watershed.

Sunggumanai Village is the area most affected by flooding every year in Pattallassang District, Gowa Regency. Based on data from the Sunggumanai Village Office, the flooding that occurred in this village was a flood that occurred due to high rainfall and overflowing River Basin Areas (DAS). The flood disaster report from the Sunggumanai Village Office recorded that on December 21-23, 2024, a flood disaster occurred which resulted in the evacuation of 17 families. Based on data from the website and data from the Sunggumanai Village Office, it shows that Sunggumanai Village, Pattallassang District, Gowa Regency is often hit by flood disasters.

This study used Sentinel-1 Synthetic Aperture Radar (SAR) satellite imagery to provide flood inundation data. SAR imagery offers the advantage of being able to produce images even in cloudy or foggy conditions without any obstructions and operating day and night. This makes SAR imagery highly valuable compared to other types of satellite imagery, which often involve cloud cover.

Research from (Anisa et al., 2023)utilizing Sentinel-1 Synthetic Aperture Radar (SAR) satellite imagery to identify flooding and damage caused by Typhoon Hagibis, which struck several areas in Japan, such as Tokyo and Fukushima. Synthetic Aperture Radar (SAR) is a type of satellite imagery that uses radar waves to map the Earth's surface.

LITERATURE REVIEW

Based on the above background, the author wants to identify the distribution of flood inundation by utilizing data from the Sentinel-1 Synthetic Aperture Radar (SAR) Satellite Imagery, flood event data, and extreme rainfall data. By raising the title Detecting the Distribution of Flood Inundation in Sunggumanai Village, Pattallassang District, Gowa Regency Using Sentinel-1 Synthetic Aperture Radar (SAR) Imagery.

METHODOLOGY

Data

This study used remote sensing data in the form of Sentinel-1 synthetic aperture radar (SAR) imagery, along with flood disaster data obtained from the Sunggumanai Village Office and rainfall data from the Meteorology, Climatology, and Geophysics Agency (BMKG) Region IV Makassar. This study was conducted in Sunggumanai Village, Pattallassang District, Gowa Regency. The data used included three scenes of Sentinel-1 satellite imagery, namely the period before the flood on August 18, 2024, when floods on December 20, 2024, and January 1, 2025. Sentinel-1 data can be downloaded for free through the Copernicus Open Access Hub (https://scihub.copernicus.eu/) or the Copernicus Data Space Ecosystem provided by the European Space Agency (ESA).

Research Flow

This study utilizes Remote Sensing technology to visualize floodwaters in the studied area. Data processing uses Sentinel-1 imagery by applying the thresholding method, commonly known as backscatter. The thresholding method is a method for displaying floodwaters according to the Area of Interest (AOI) using the Sentinel image processing application, the Sentinel Application Platform (SNAP).

Statistical analysis

Statistical analysis was performed to evaluate the flood detection results. Accuracy was calculated using a confusion matrix, which yielded an Overall Accuracy (OA) value as the classification result. Furthermore, statistical analysis was used to determine the threshold value for the SAR imagery. The threshold value calculation used in this study was based on that of Long et al., 2014, and is described in the following equation (Nasution & Nurtyawan, 2020).

Threshold (Threshold) = PD<({$\boldsymbol{\mu}$}−$\boldsymbol{kf}$×{$\boldsymbol{\sigma}$}) ..... (1)

PD = Flood inundation identified pixels

$\boldsymbol{\mu}$= Mean (average)

$\boldsymbol{\sigma}$= Sigma (standard deviation)

kf determined at 1.5

The accuracy testing method used was a confusion matrix to determine the overall accuracy value (Brillyansyah et al., 2022). The accuracy test was conducted using a confusion matrix with three main parameters:

User accuracy = xii X 100% ..... (2)

x+i

Manufacturer accuracy = xii X 100% ..... (3)

xi+

Overall accuracy = 1xii X 100% ..... (4)∑_i^r▒ 〖= 〗

N

Information :

Xii = diagonal value of the contingency matrix of row -i and column -i

X + i = number of points in the i-th column

Xi + = number of points in the i-th row

N = total of all sample points

RESULTS AND DISCUSSION

In this study, the data used consisted of SAR satellite imagery, flood event data, rainfall data, and disaster risk data. The collected data was then processed to detect the distribution of floodwaters and test the accuracy of the use of Sentinel-1 Synthetic Aperture Radar (SAR) imagery data for flooding that occurred in Sunggumanai Village, Pattallassang District, Gowa Regency. The results of the accuracy test are shown in the following figure and table.

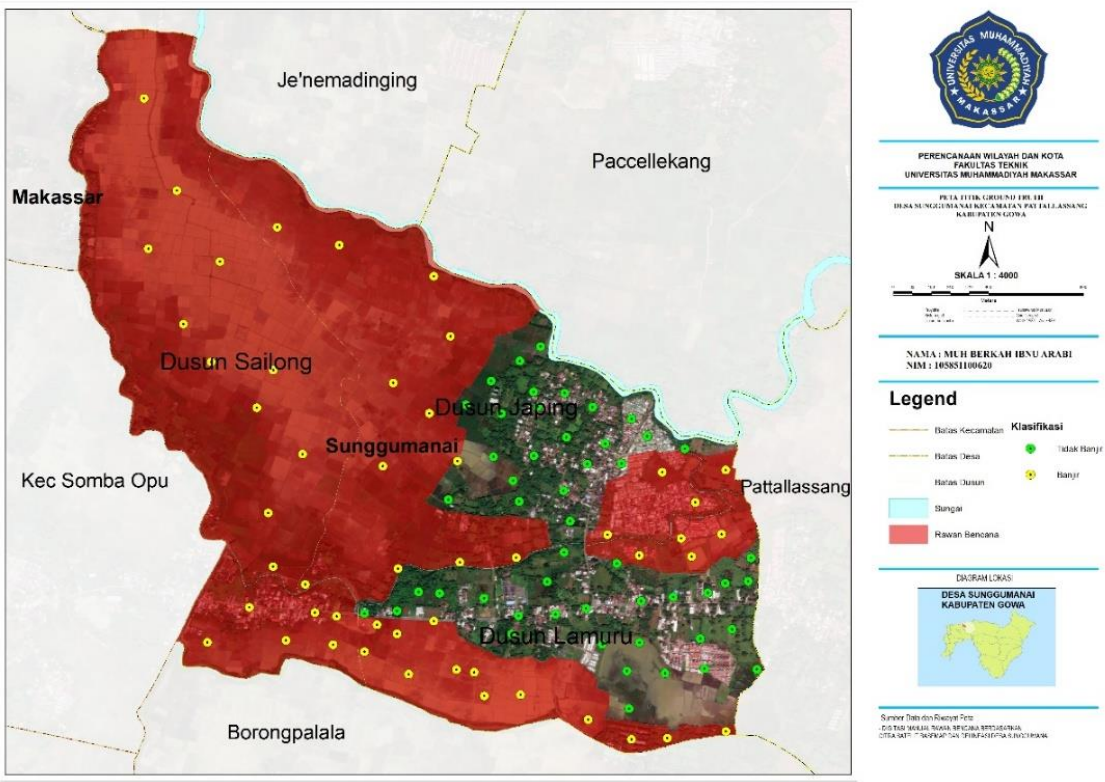


Figure 1. Map of Ground Truth Distribution Points

Table 1. Validation Data Based on Image Observations and Sentinel-1 SAR

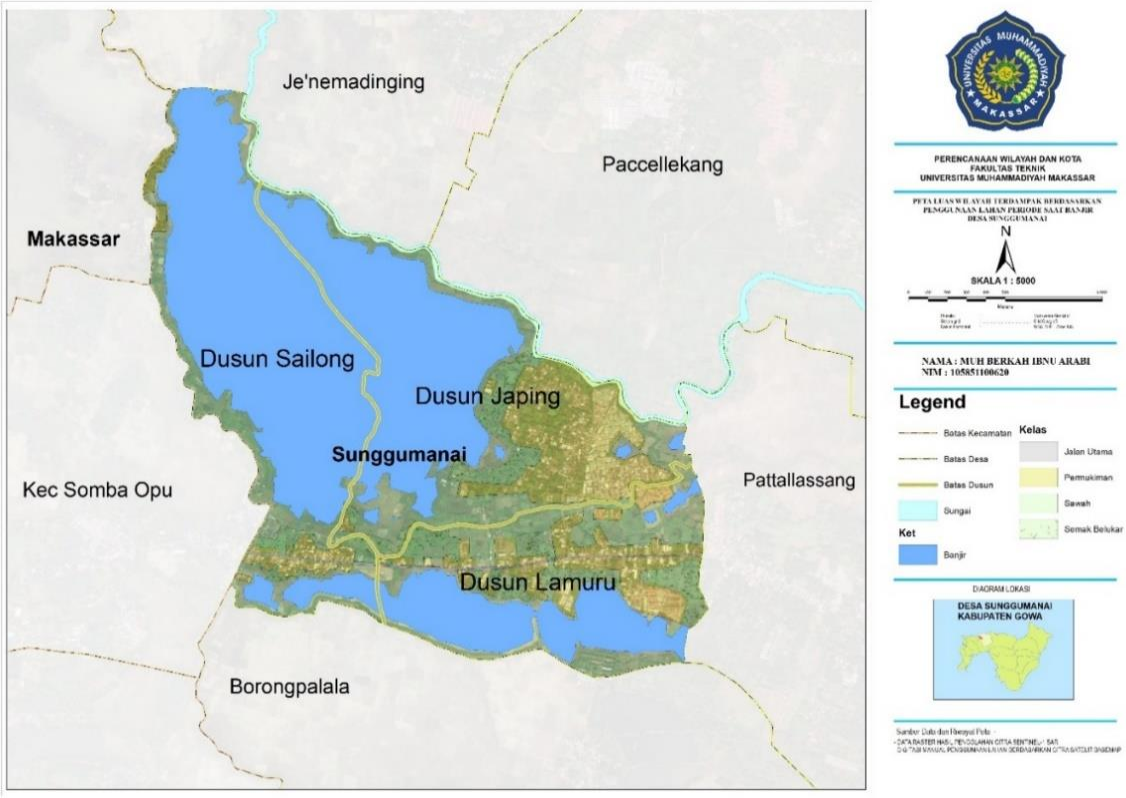
Information		Observation		Number of Predictions
		No Flood	Flood	
Prediction	No Flood	43	18	61
	Flood	7	32	39
Number of Observations		50	50	100

Based on the results of the ArcGIS analysis, 50 samples were detected as not flooded in the ground truth data (observation), which in the Sentinel-1 SAR image were detected as not flooded as many as 43 samples and detected as

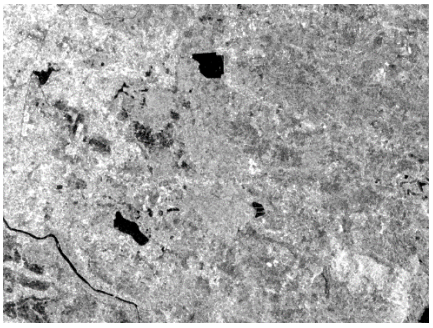
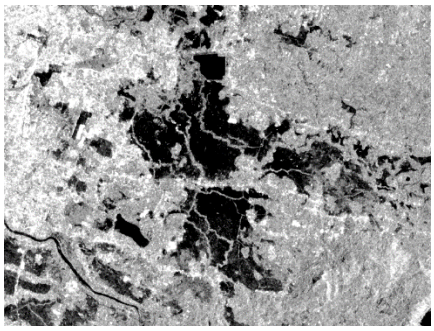
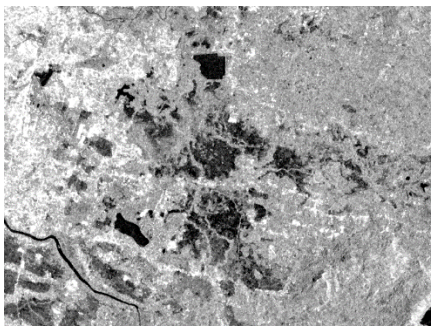
flooded as many as 7 samples. Meanwhile, 50 samples were detected as flooded in the ground truth data, in the Sentinel-1 SAR image were detected as flooded as many as 32 samples and detected as not flooded as many as 18 samples. The overall accuracy results show (Overall Accuracy) that overall the results of the Sentinel1 SAR image classification using ArcGIS are correct for 75% of the sample points tested. Based on these values, flood predictions from Sentinel-1 images and observation data from the ground truth are classified into "Good Enough" category.

Sentinel-1 Synthetic Aperture Radar (SAR) satellite imagery data uses three image scenes: before, during, and after the flood. Data from these three image scenes will then be processed using the Sentinel Application Platform and ArcGIS software to detect the distribution of floodwaters in Sunggumanai Village, Pattallassang District, Gowa Regency. The results of the floodwater distribution detection can be seen in the following image.

Table 2. Sentinel-1 SAR Image Pre-Processing Stage



CONCLUSION AND RECOMMENDATION

Sentinel-1 SAR Image Pre-Processing Stage	Information
	Sentinel-1 image before the flood event (recording date 18 August 2024)
	Sentinel-1 imagery during the flood event (recording date 20 December 2024)
	Sentinel-1 image after the flood event (recording date 01 January 2025)

Memberikan beberapa kesimpulan dan implementasi dari hasil penelitian. Figure 2 map of the distribution of standing water during the flood period

The analysis results during the flood show the extent of the flood-affected area in Sunggumanai Village, Pattallassang District, Gowa Regency on a broader and more striking spatial scale. Based on map analysis and spatial processing, the flood inundation area covers 264 hectares. This flood area includes 264 hectares of rice fields and 0.3 hectares of residential areas. Compared to the area of inundation during the pre-flood period (inundation area of only 1.17 hectares), this map depicts a large-scale flood event with the potential to inundate densely populated residential areas.

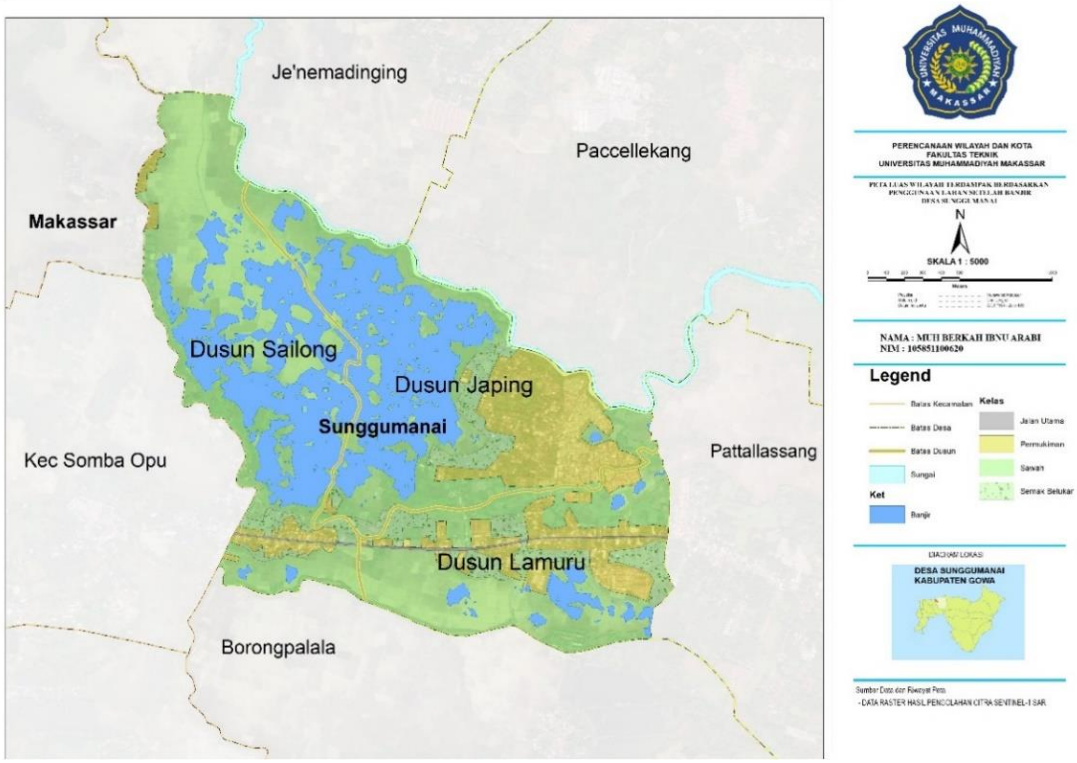


Figure 3. Map Of The Distribution Of Standing Water During The Flood Period

In the post-flood period, the water level decreased. Based on the results of spatial classification and analysis, the total floodwater area was recorded at 137 hectares. This area indicates the extent of the inundation area after the flood, as water began to spread and inundate low-lying areas. This figure is slightly smaller than at the peak of the flood (previously 264 hectares), indicating a decrease in the inundation area due to the receding waters.

CONCLUSION AND RECOMMENDATION

The results of flood inundation distribution detection show that in the period before the flood on August 18, 2024, the affected area was only 1.17 hectares, while in the period during the flood on December 20, 2024, the affected area was 264 hectares, most of which were affected by rice fields. In the period after the flood, the affected area decreased by 137 hectares. The total area of Sunggumanai Village is 487 hectares. Based on this analysis, the affected area during the flood was approximately 54% of the total area dominated by productive agricultural land. In this case, the flood had an impact on agricultural activities in the area. The results of Sentinel-1 synthetic aperture radar (SAR) image detection show the distribution of areas affected by flooding in Sunggumanai Village, Pattallassang District, Gowa Regency.

The accuracy evaluation results showed an overall accuracy score of 75%. This value indicates that the accuracy test results performed have a fairly good level of accuracy and can be used as a reference for risk analysis and flood disaster management.

FUTHER STUDY

This research still has delays, so it is necessary to conduct further research related to the topic Detecting the Distribution of Flood Inundation in Sunggumanai Village, Pattallassang District, Gowa Regency Using Sentinel-1 Synthetic Aperture Radar (SAR) in order to improve this research and add insight for readers.

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